FINAL REPORT

STUDY OF PHOTOEMISSION AND WORK FUNCTION OF LARGE SURFACE AREAS

PHASE III

1 JULY 1971 - 15 DECEMBER 1971

PHASE IV

1 JULY 1972 - 31 MAY 1973

CONTRACT NO.: NAS-5-11138

AVSD-0295-73-RR

GODDARD SPACE FLIGHT CENTER

CONTRACTING OFFICER: J. R. HIGGINS
TECHNICAL MONITOR: T. AGGSON

PREPARED BY

AVCO CORPORATION
SYSTEMS DIVISION
NGTON, MASSACHUSETTS 01887

FOR

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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I. INTRODUCTION

The Phase III and IV work to be discussed in this report is a part of the sequence of studies (1) of the photoemission of materials which might be used in probe measurements of the exo-atmospheric electric field. It was recognized in the earlier phases that a serious error in the probe measurement could result from an imbalance in photoemission from the two antennae. One can easily imagine one antenna probe being exposed to direct sunlight while the other is partially shaded by the vehicle. The fact that the photocurrents are unequal would appear as a voltage comparable to the potential difference which is sought. As a technique to minimize this problem, one can seek materials and coating which emit the smallest photocurrent.

Tasks of Phase I and II were to measure the relative total photoemission from samples of several engineering materials. These data together with the results of contact potential measurements were to be used in the selection of preferred materials for probe fabrication.

A theoretical task in Phase II examined the mechanisms of photoemission as postulated by Fowler (2) and Hinteregger (3) and the expressions for photoelectric yield which resulted from these two different theories. As part of Phase II, the impact of these theories upon the problem of emission minimization was examined. It was found that the theories did not give a complete picture of the photoelectric yield and that a gap in the predictions of the two theories fell just where the solar spectral curve rose most steeply. One should, therefore, study not only the total emitted current as was done in Phases I and II but also examine the yield spectrum in detail over a wide range of incident photon energies.

Phase III has been a two-pronged study of the wavelength dependence of photoelectric yield. In the next section of this report the results of a literature survey will be presented. The absolute yield data for eleven materials as a function of wavelength has been collected and plotted over the range 800 to 3200 Å. Section III will describe modifications which have been made to the experimental apparatus at Avco to allow the measurement of relative yield as a function of wavelength over the range 2000 to 4000 Å. The results of measurements made with some of the samples used in the earlier phases are given. In the final sections of this report the yield data will be evaluated in terms of the solar spectrum and figures of merit will be developed.

Additional experimental measurements have been added to the study as Phase IV. The results of these measurements have been integrated into the final report which had been written for Phase III; ~~this~~ report is the resulting document.

II ABSOLUTE PHOTOELECTRIC YIELD

The absolute photoelectric yield of a material is the number of photoelectrons emitted from the material divided by the number of photons, of a particular energy, incident upon the surface of the material. Some authors will correct for reflection losses and use the number of photons absorbed. For this study of the effect of solar radiation, the incident number is the more realistic definition.

The search for yield data in the literature has produced several sources in the vacuum ultraviolet (λ less than 1500 Å) but much less data at longer wavelengths. Also, most of the long wavelength data is found in references before 1935. As will be pointed out in the case of zinc, the methods of sample preparation lead us to discount some of these earlier results. In Table I the materials are listed with the figure numbers of the yield plots and the reference citations. Where no data was found, a dotted line in the figures indicates extrapolation.

The first group of figures (1-4) includes the free-electron type metals. They all exhibit yields at the longer wavelengths (~ 3000 Å). Silver, gold, and platinum show an inflection point or cusp. This is interpreted as indicating the presence of impurities in the sample such as surface contamination.

The refractory metals, tungsten and tantalum, and nickel (Figures 5-7) show a cut-off for the yield curve between 2200 and 2500 Å.

Certain materials are found to have yield curves (Figure 8-11) that drop most steeply, cutting off at 2000 Å or less. Aluminum, cadmium, and zinc from groups two and three of the periodic table together with copper-beryllium, an alloy, are in this class.

It was stated earlier that some selectivity has been used in the presentation of these yield data. As a case in point we may look at zinc. Suhrmann and Pietrzyk [11] have published yield values for zinc in the 2300 or 2800 Å region. Several of their data points are reproduced in Figure 10. An explanation for these high yields at long wavelengths may be found in the type of sample use for these measurements and the method of its formation. It turns out that these zinc samples (as well as other aluminum and cadmium samples reported in the same paper) were thin evaporated films generated in only moderate vacuum at a low rate. It can be safely assumed that the substrate and the presence of impurities would have a strong influence on the photoelectric yield of this kind of sample.

TABLE I
YIELD DATA SOURCES

MATERIAL	FIGURE	WAVELENGTH BAND	REFERENCE
Aluminum	8	800-1200	(4)
		800-1440	(5)
		1000-1600	(6)
Cadmium	9	800-1440	(5)
		900-1800	(6)
Copper	1	800-1200	(4)
		800-1400	(7)
		900-2000	(6)
Copper-Beryllium	11	900-1500	(4)
Gold	3	800-1200	(4)
		800-1440	(5)
		800-1000	(7)
		2250-2750	(8)
Nickel	5	800-1300	(4) (7)
		800-1900	(6)
Platinum	4	800-1200	(4)
		800-1400	(7)
		800-2000	(6)
		2250-2750	(8)
		2000-2500	(9)
Silver	2	800-1400	(5)
		950-1200	(4)
		800-1000	(7)
		2250-2950	(8)
		900-2000	(6)
Tantalum	6	900-1600	(6)
Tungsten	7	800-1000	(7)
		800-1300	(4)
		800-1600	(6)
		1000-1400	(10)
Zinc	10	800-1200	(4)
		900-1700	(6)
		2300-2800	(11) (see text)

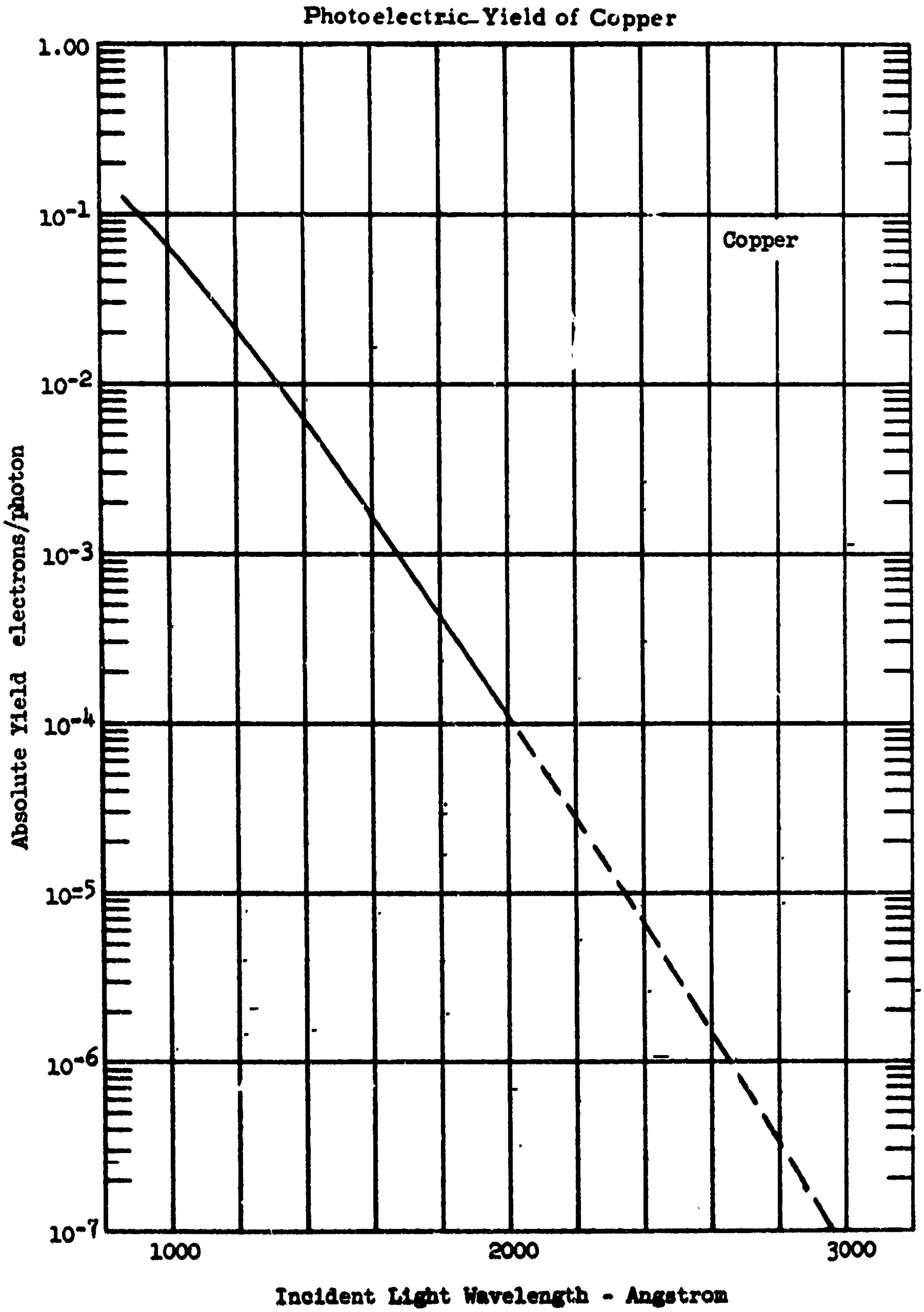

Photoelectric Yield of Copper
1.00
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Copper
Absolute Yield electrons/photon
1000
2000
3000
Incident Light Wavelength - Angstrom

Figure 1

Photoelectric Yield of Silver

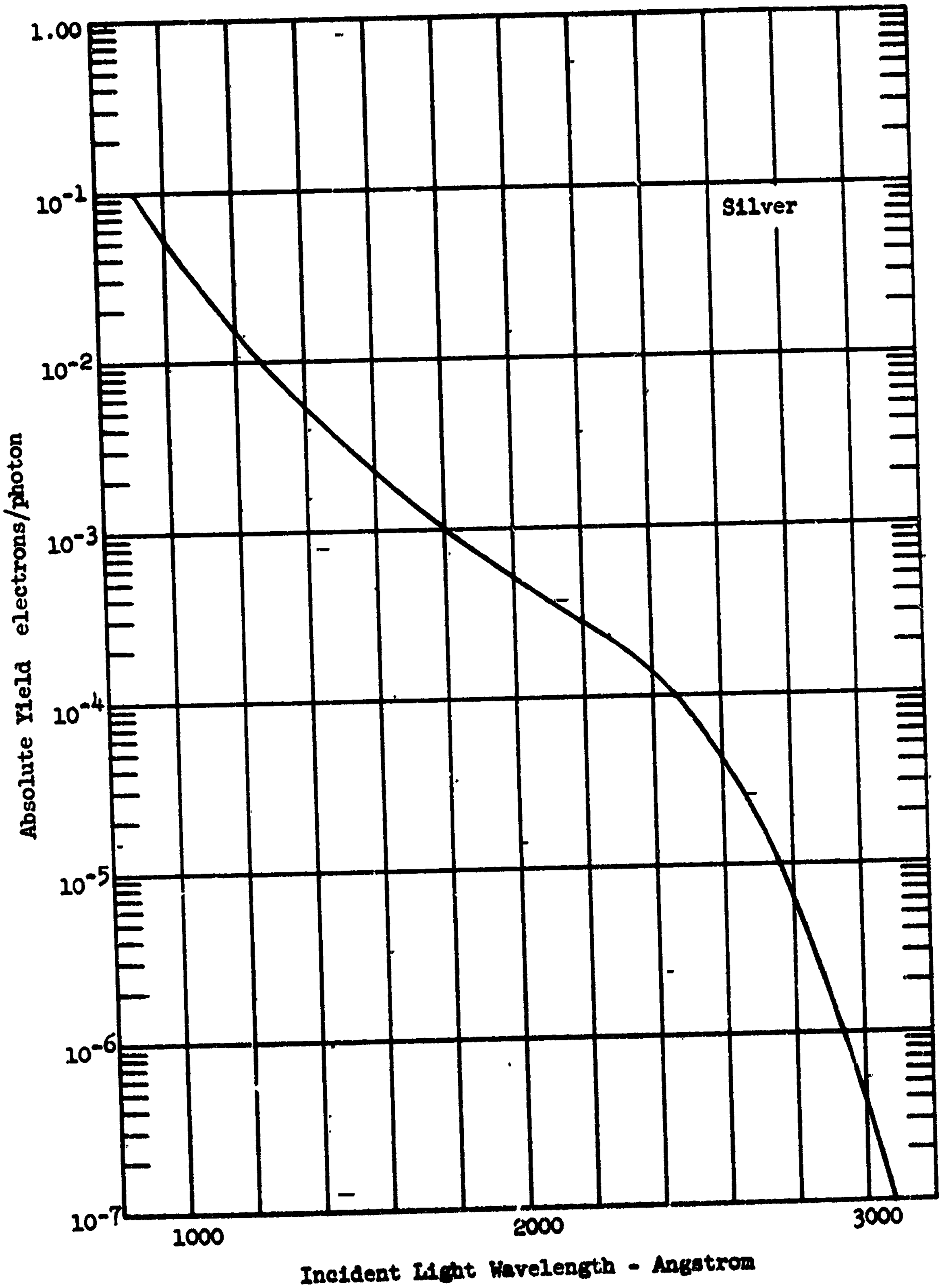


Figure 2

Photoelectric Yield of Gold

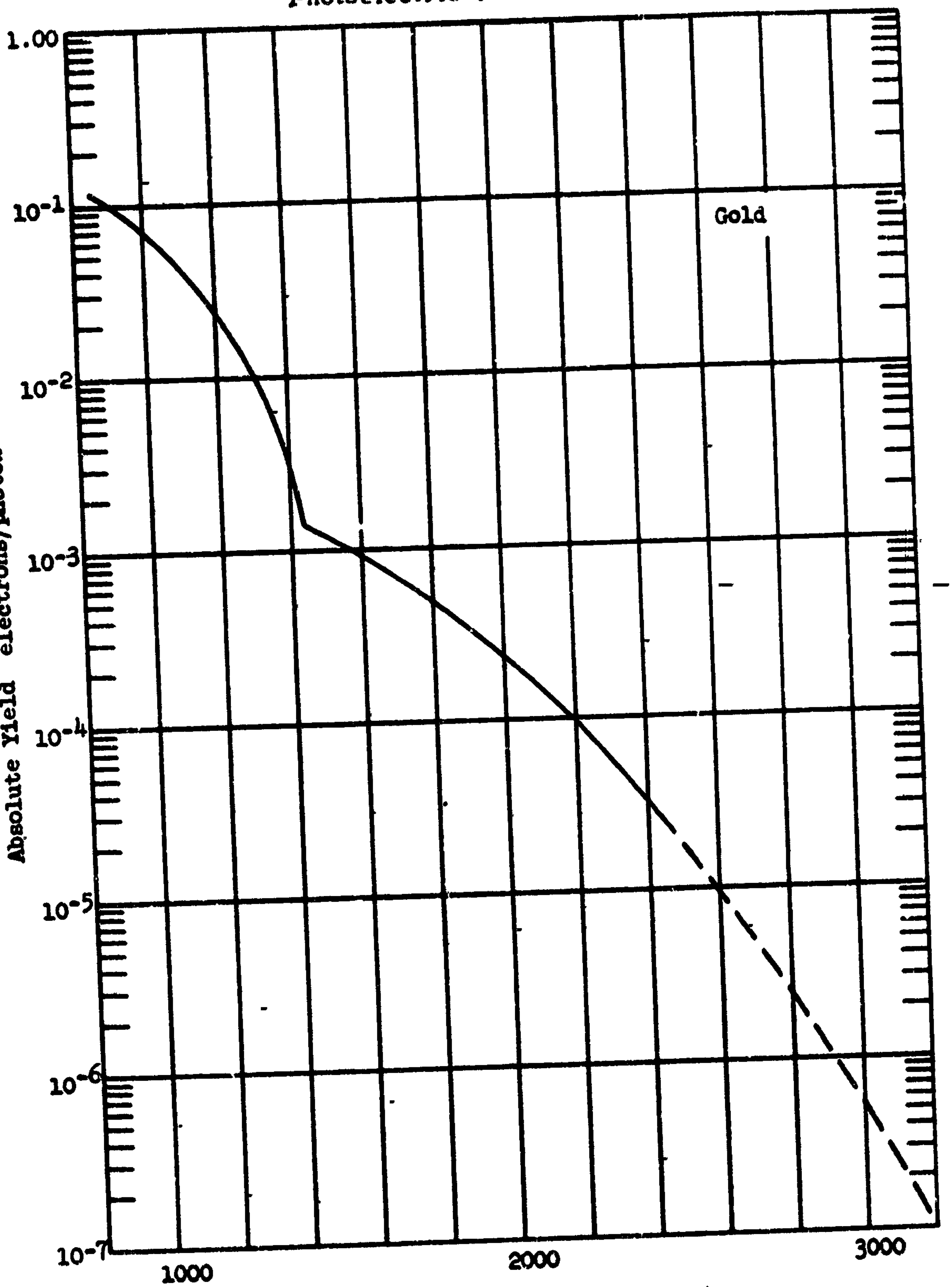


Figure 3

Photoelectric Yield of Platinum

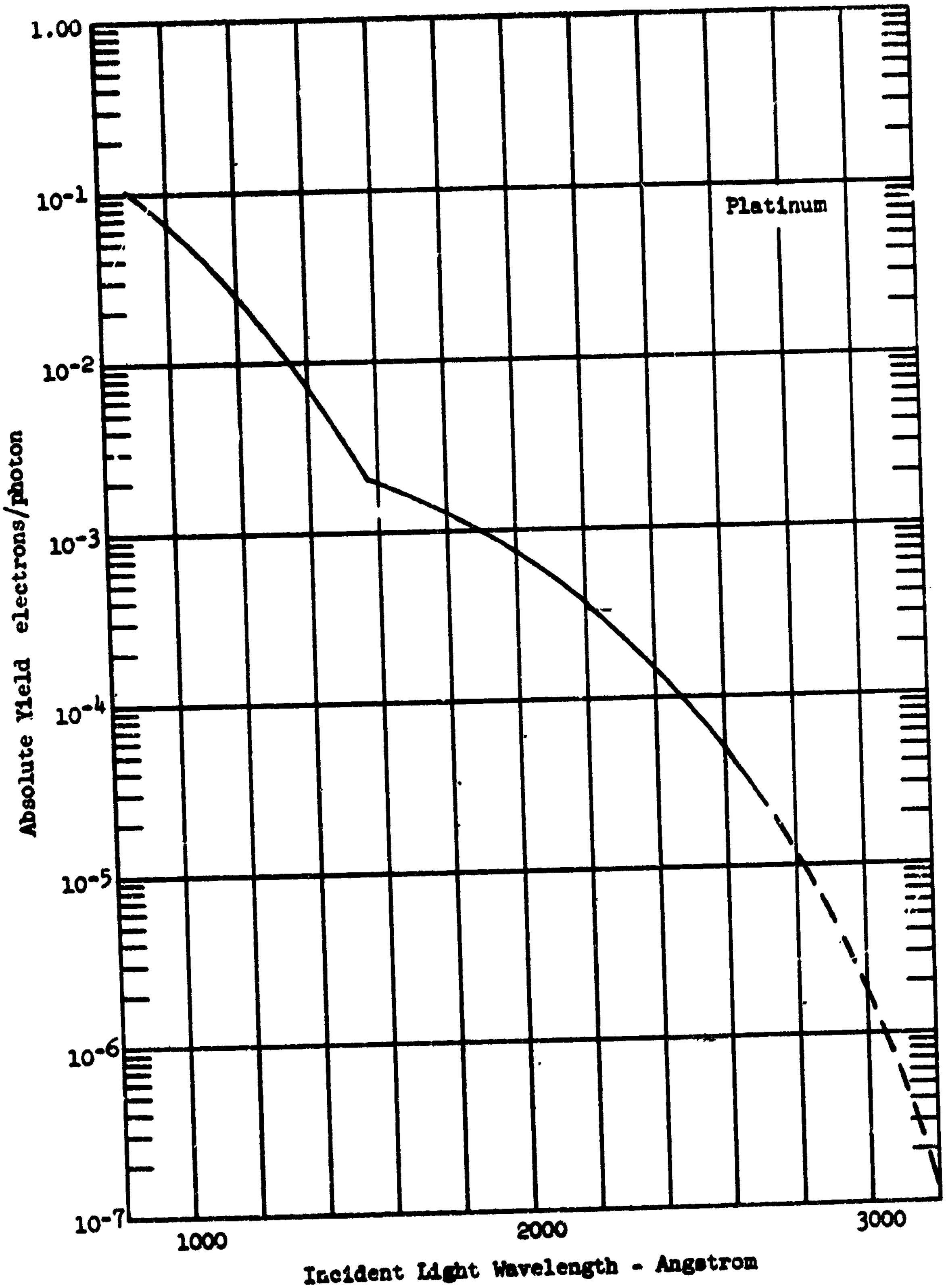
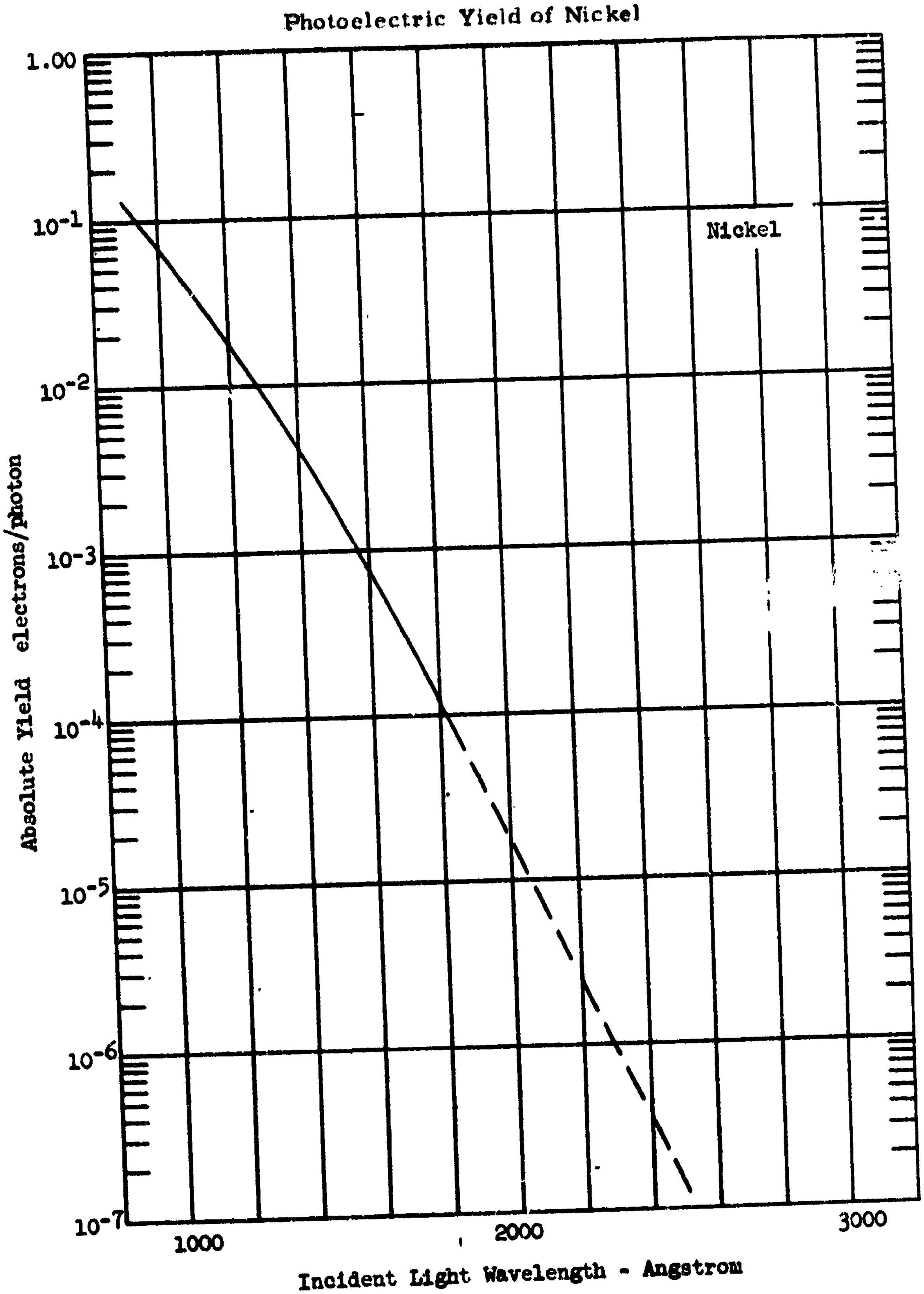


Figure 4



Photoelectric Yield of Nickel
1.00
10-1
10-2
10-3
10-4
10-5
10-6
10-7
Nickel
Absolute Yield electrons/photon
1000
2000
3000
Incident Light Wavelength - Angstrom

Figure 5

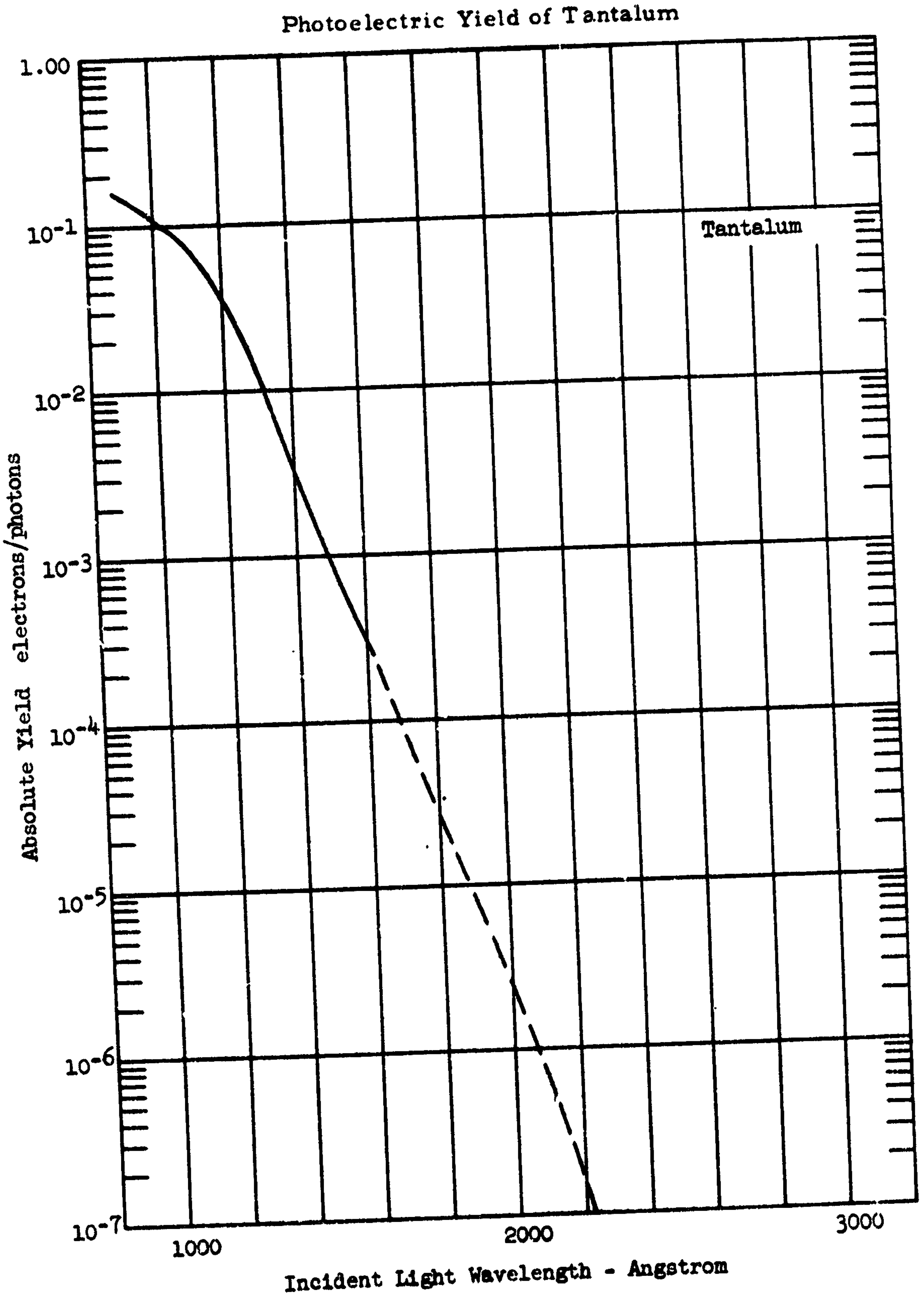

Photoelectric Yield of Tantalum
1.00
10-1
10-2
10-3
10-4
10-5
10-6
10-7
Tantalum
Absolute Yield electrons/photons
1000
2000
3000
Incident Light Wavelength - Angstrom

Figure 6

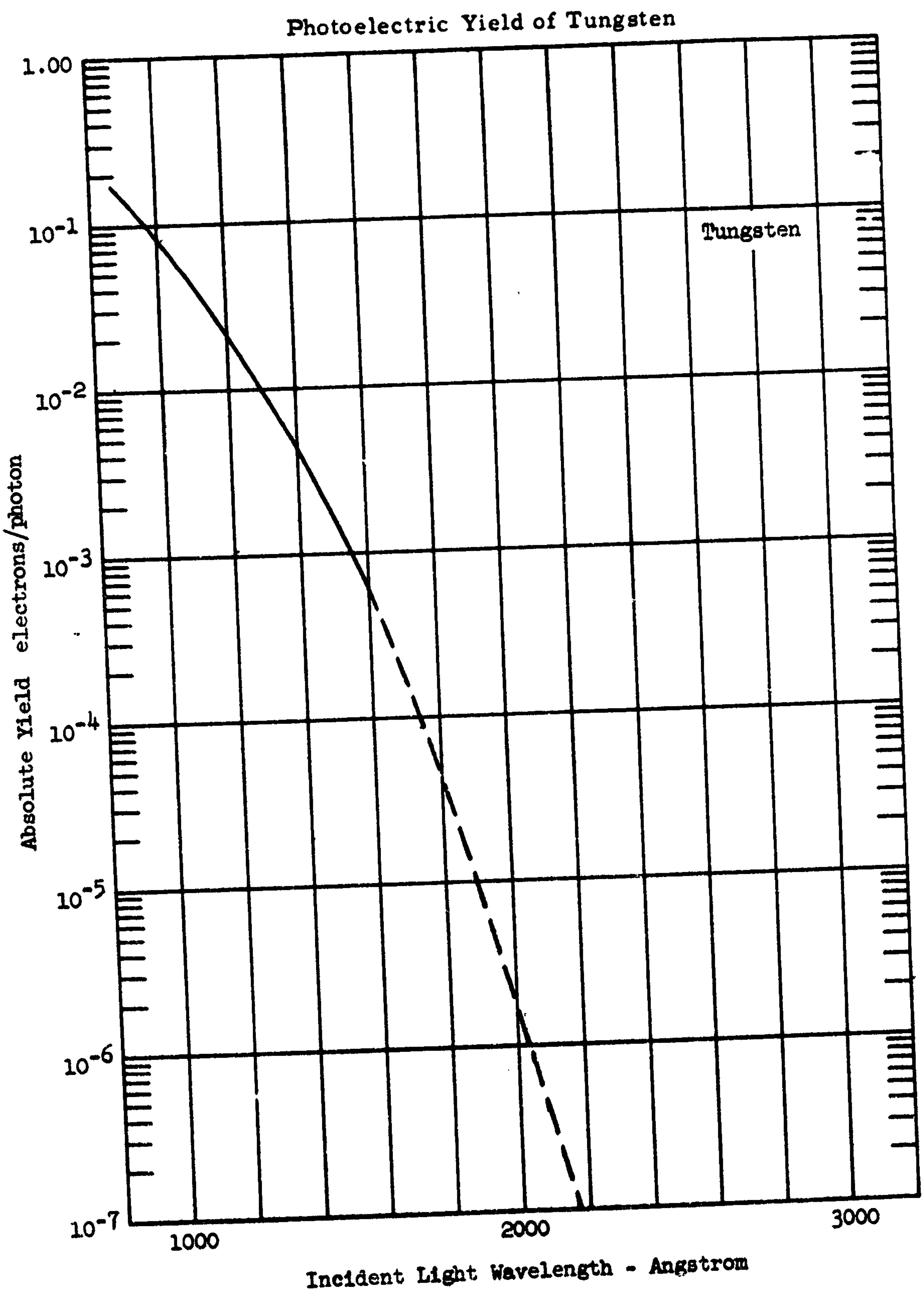

Photoelectric Yield of Tungsten
1.00
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Absolute Yield electrons/photon
Tungsten
1000
2000
3000
Incident Light Wavelength - Angstrom

Figure 7

Photoelectric Yield of Aluminum

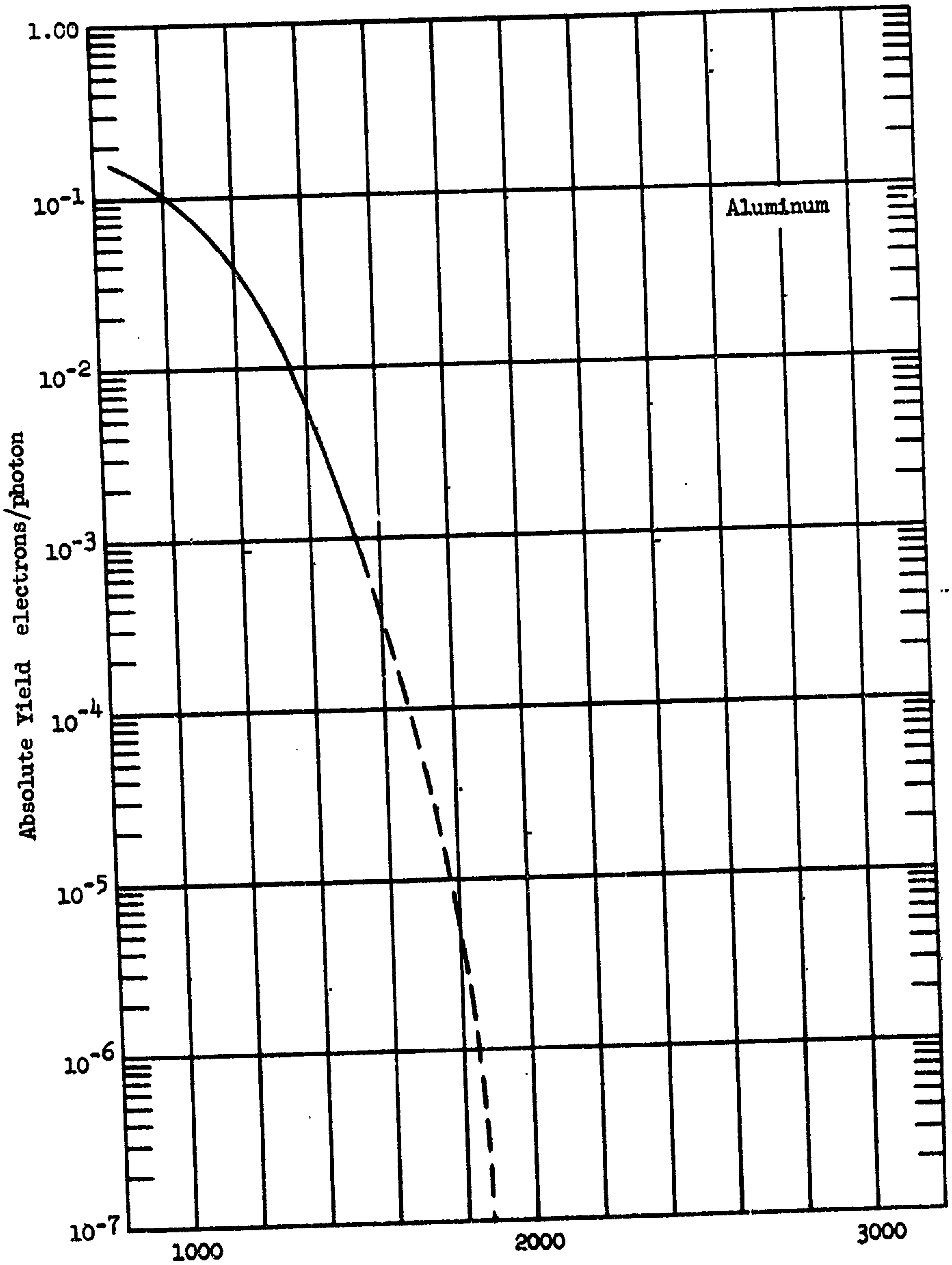


Figure 8

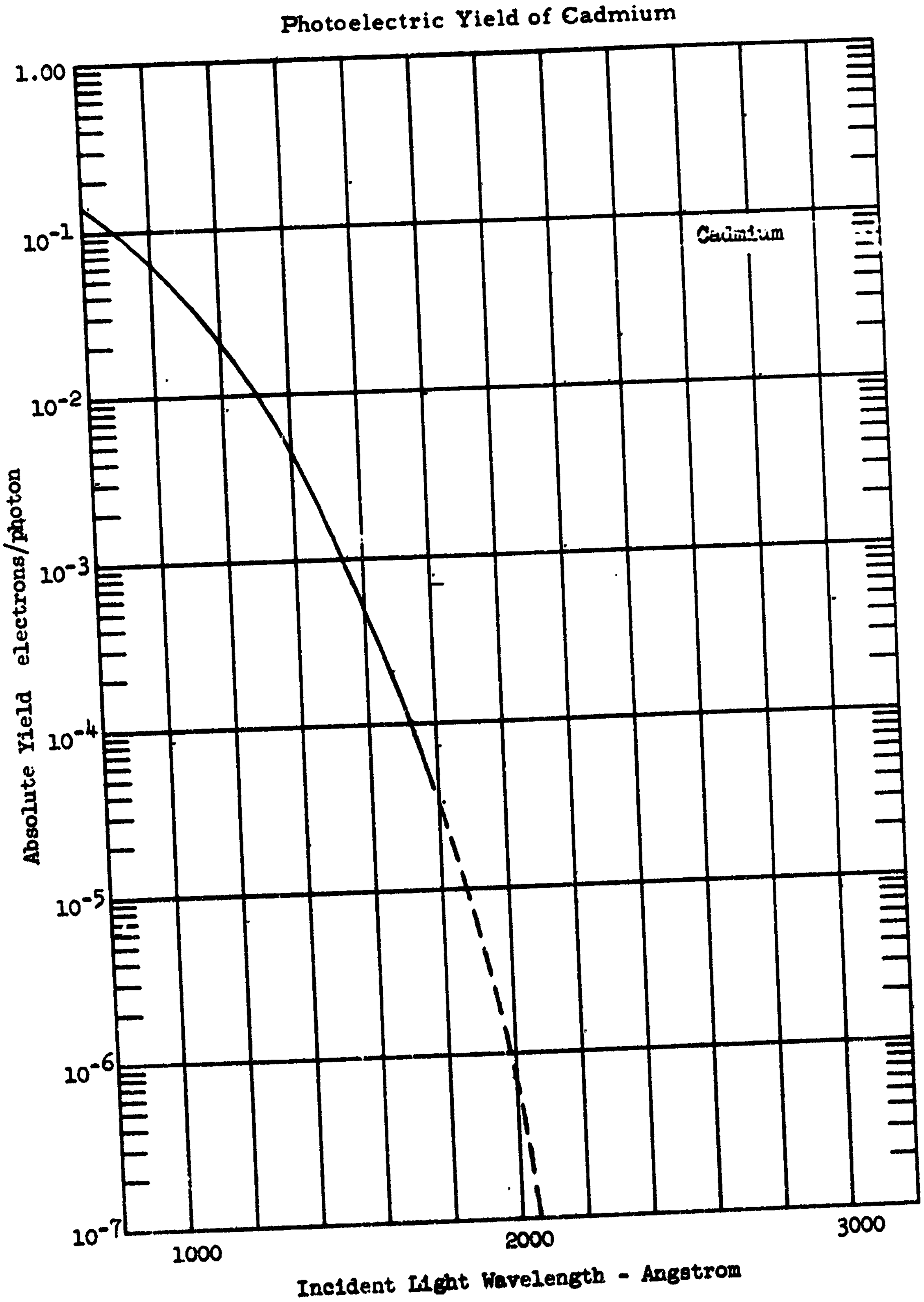

Photoelectric Yield of Cadmium
1.00
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Absolute Yield electrons/photon
Cadmium
1000
2000
3000
Incident Light Wavelength - Angstrom

Figure 9

Photoelectric Yield of Zinc

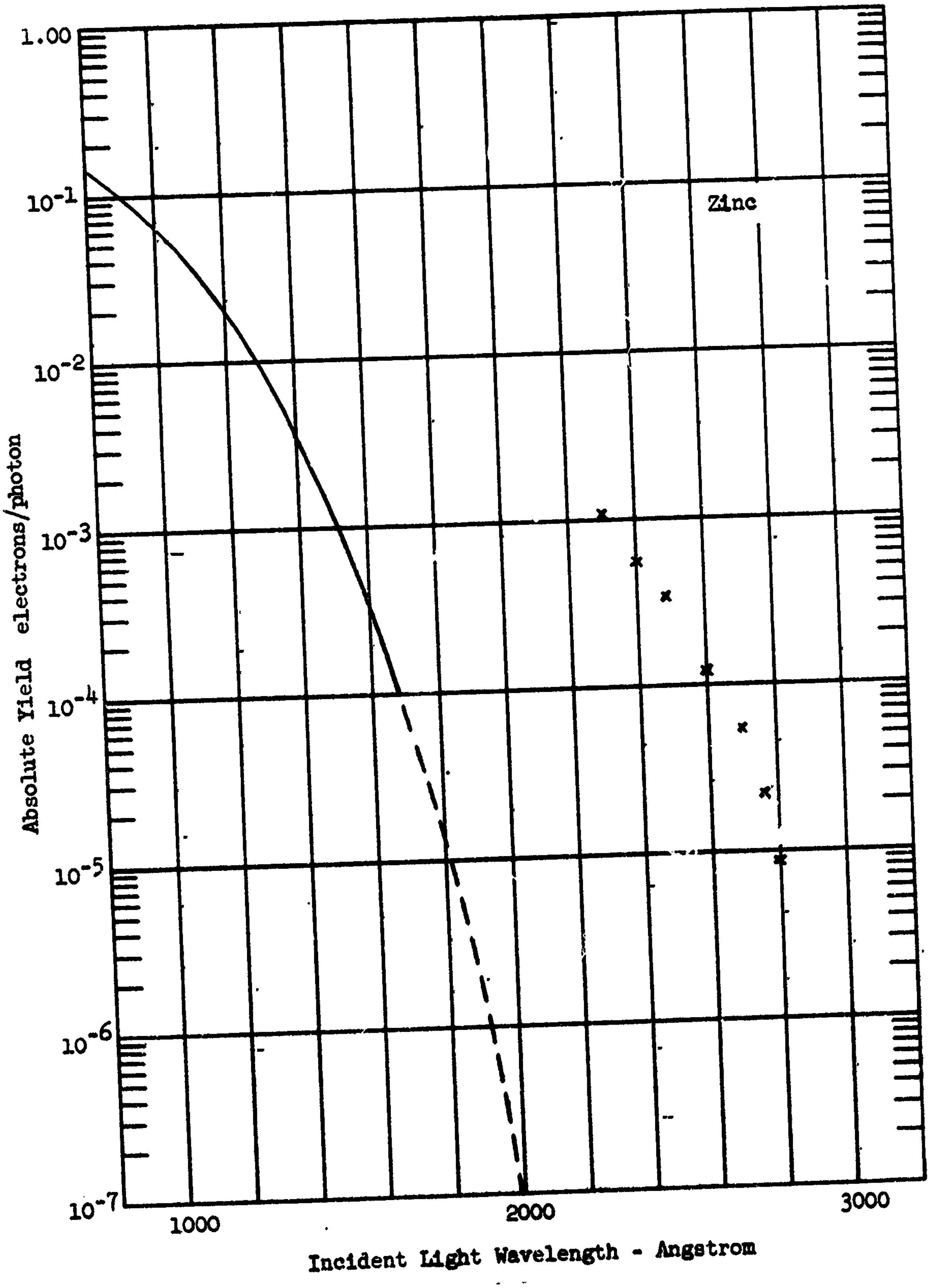


Figure 10

Photoelectric Yield of Copper-Beryllium

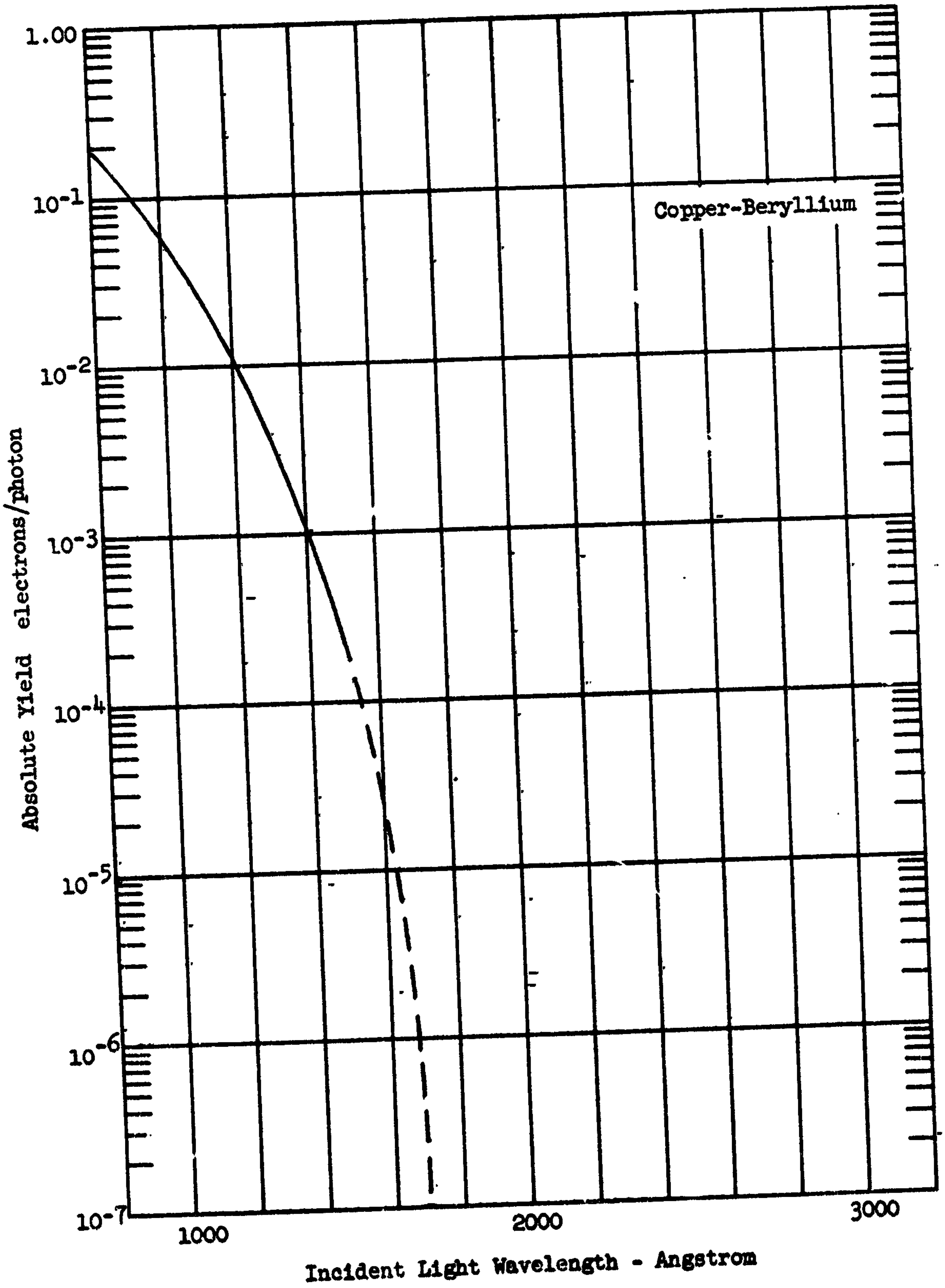


Figure 11

III. EXPERIMENTAL STUDY

The basic apparatus used for the measurement of photoemission has been described in earlier reports ([1]). The modifications necessary to make yield measurements as a function of wavelength are included in Figure 12. The same high-pressure mercury arc lamp is used as the light source. A Bausch and Lomb monochromator has been inserted in the optical path between the quartz focussing lens and the sapphire window of the vacuum chamber. For these measurements the shutter, used in Phase II to produce light pulses, is not used. The samples which have been tested are all electrical conductors, therefore, the complications of pulse measurements can be avoided.

The steady state photocurrent is collected by the plate which is biased at +45 volts by the potentiometer R_p and a battery. After being amplified, this current is displayed on a strip-chart recorder. By starting the wavelength drive of the monochromator one can trace out a curve of photocurrent versus wavelength with the recorder. Figure 13 shows the observed potoemission current from a zinc sample. (The spike at 4300 Å is due to noise as is the disturbance at 3600 Å).

To convert the measured photocurrent to relative yield, it must be normalized by dividing it, point-by-point, by the relative spectral lamp intensity. To measure the lamp output a photomultiplier is placed at the exit slit of the monochromator (Figure 14). The window of the photomultiplier is coated with sodium salicylate phosphor to extend the sensitivity into the ultraviolet. The output of the photomulitplier passes through a logarithmic voltage compressor and can be plotted on a recorder as a function of wavelength. A lamp calibration curve taken in this manner is shown in Figure 15.

In Phase III, measurements of the relative yield of the eight materials listed in Table II were made as a function of wavelength. Data of the type shown in Figure 13 have been normalized by the appropriate lamp spectrum. The normalized experimental points are plotted in Figures 16-23. These data have also been compared with the values of absolute yield which have been reported from the literature. A scaling factor has been selected which will bring the Avco data for gold and silver into agreement with the curves in Figures 3 and 2 respectively. The dotted curves in Figures 16-22 represent the curves in Figures 3, 2, 1, 6, 7, 10, and 11 all multiplied by the same scaling factor.

The experimental procedure for the measurements made in Phase IV was identical to the procedure, already described, used in Phase III. The objective of Phase IV was to measure the relative photoelectric yield of three classes of materials: alloys, coated dielectrics, and graphite. A complete listing of the Phase IV test materials is given in Table III.

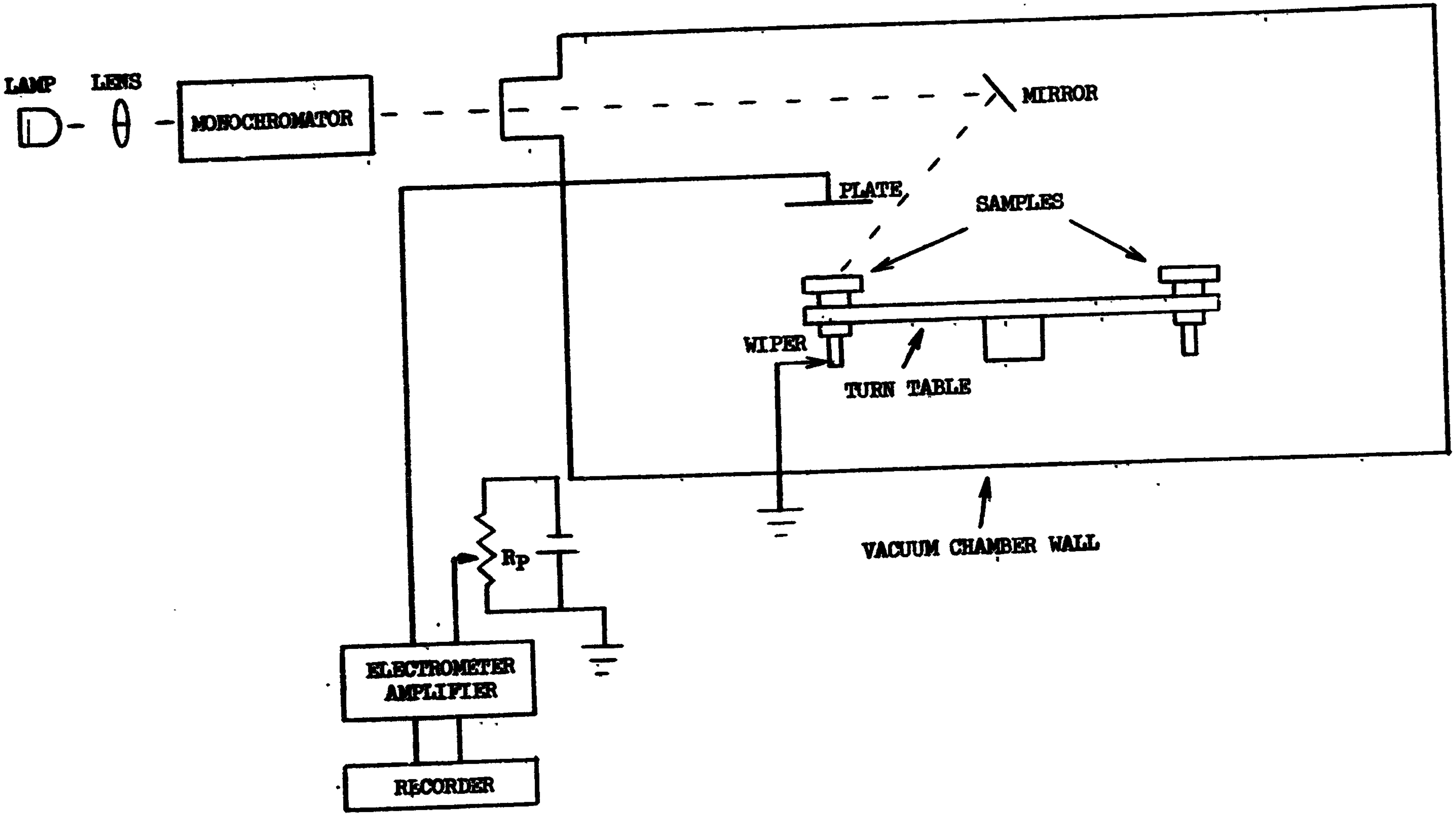


FIGURE 12. EXPERIMENTAL APPARATUS

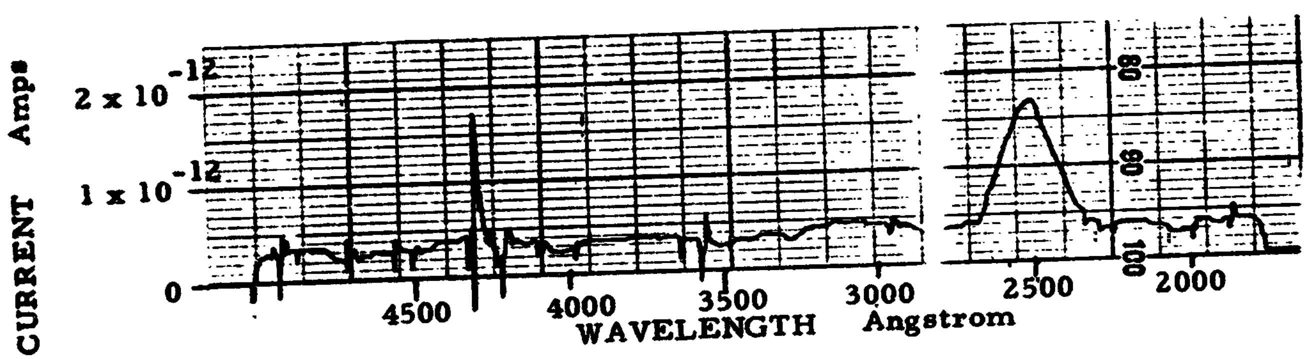


Figure 13

Observed Photoemission from Zinc

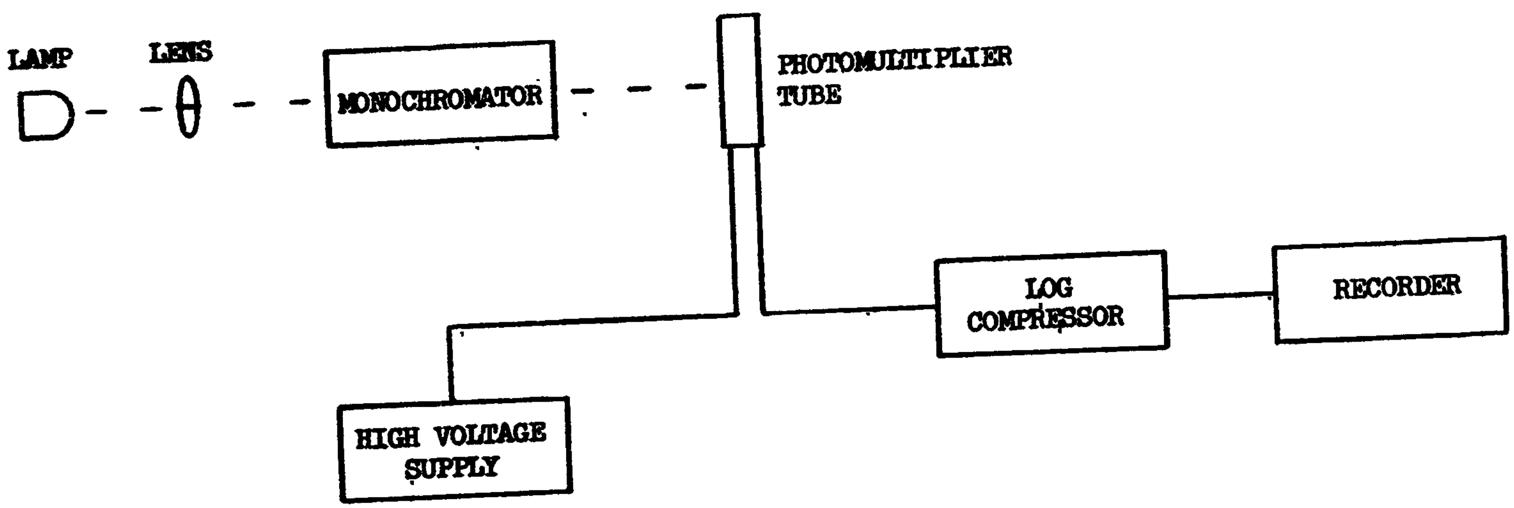


FIGURE 14. LAMP OUTPUT MEASUREMENT

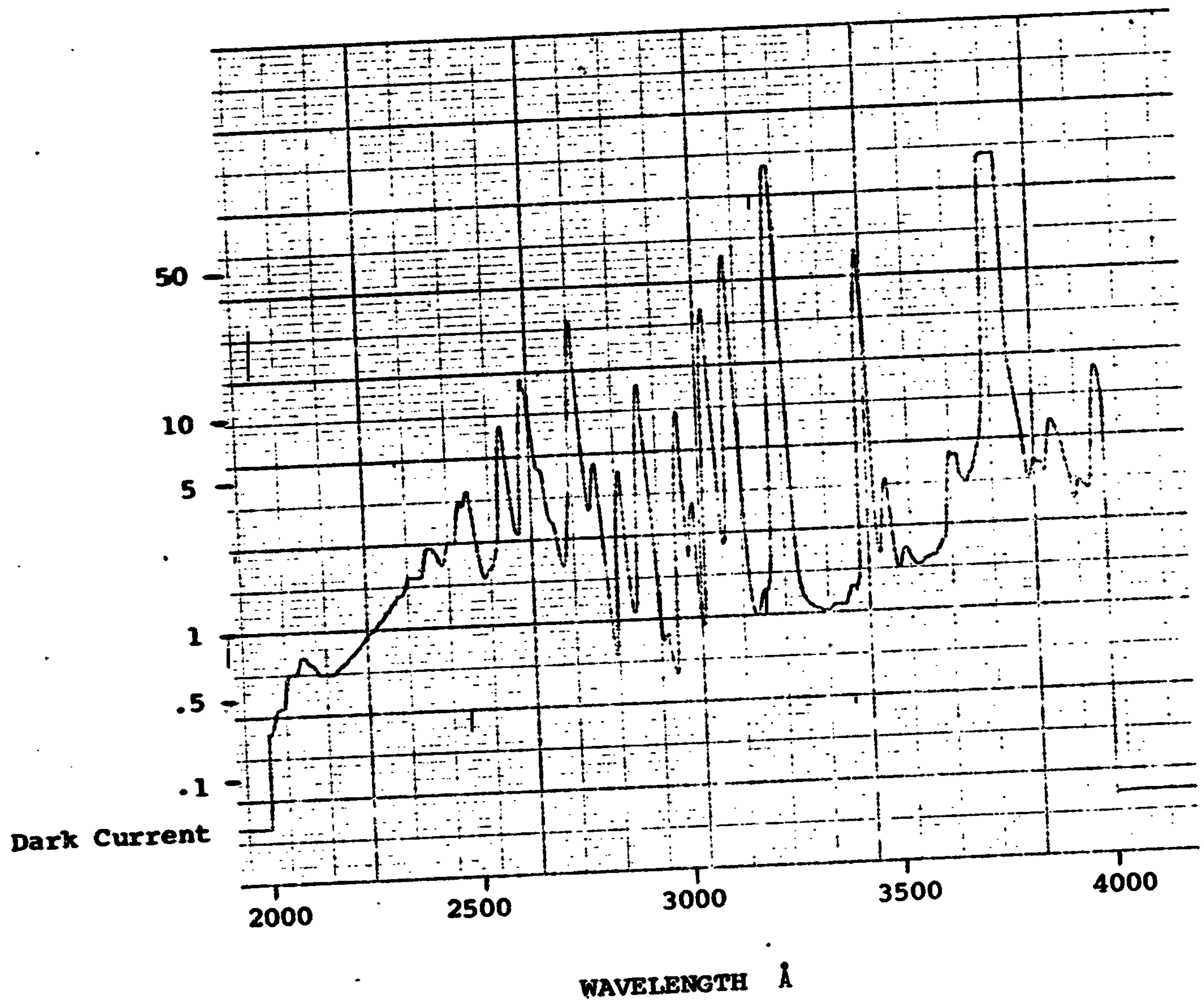


FIGURE 15

LAMP CALIBRATION

TABLE II

TEST MATERIALS - PHASE III

Carbon

Copper

Copper-Beryllium

Gold

Silver (3 samples)

Tantalum

Tungsten (2 samples)

Zinc (2 samples)

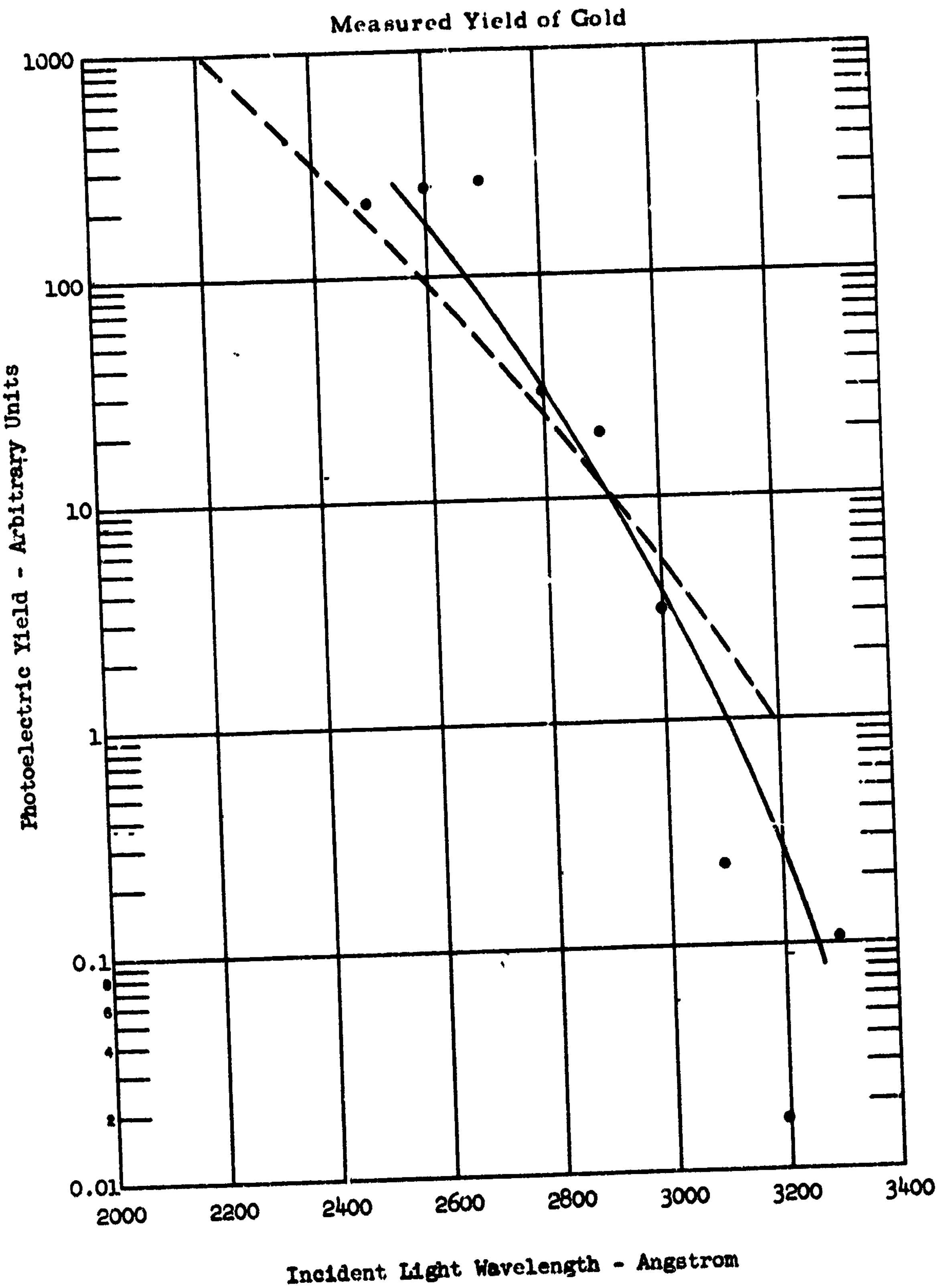

Measured Yield of Gold
1000
100
10
1
0.1
8
6
4
2
0.01
2000
2200
2400
2600
2800
3000
3200
3400
Photoelectric Yield - Arbitrary Units
Incident Light Wavelength - Angstrom

Figure 16

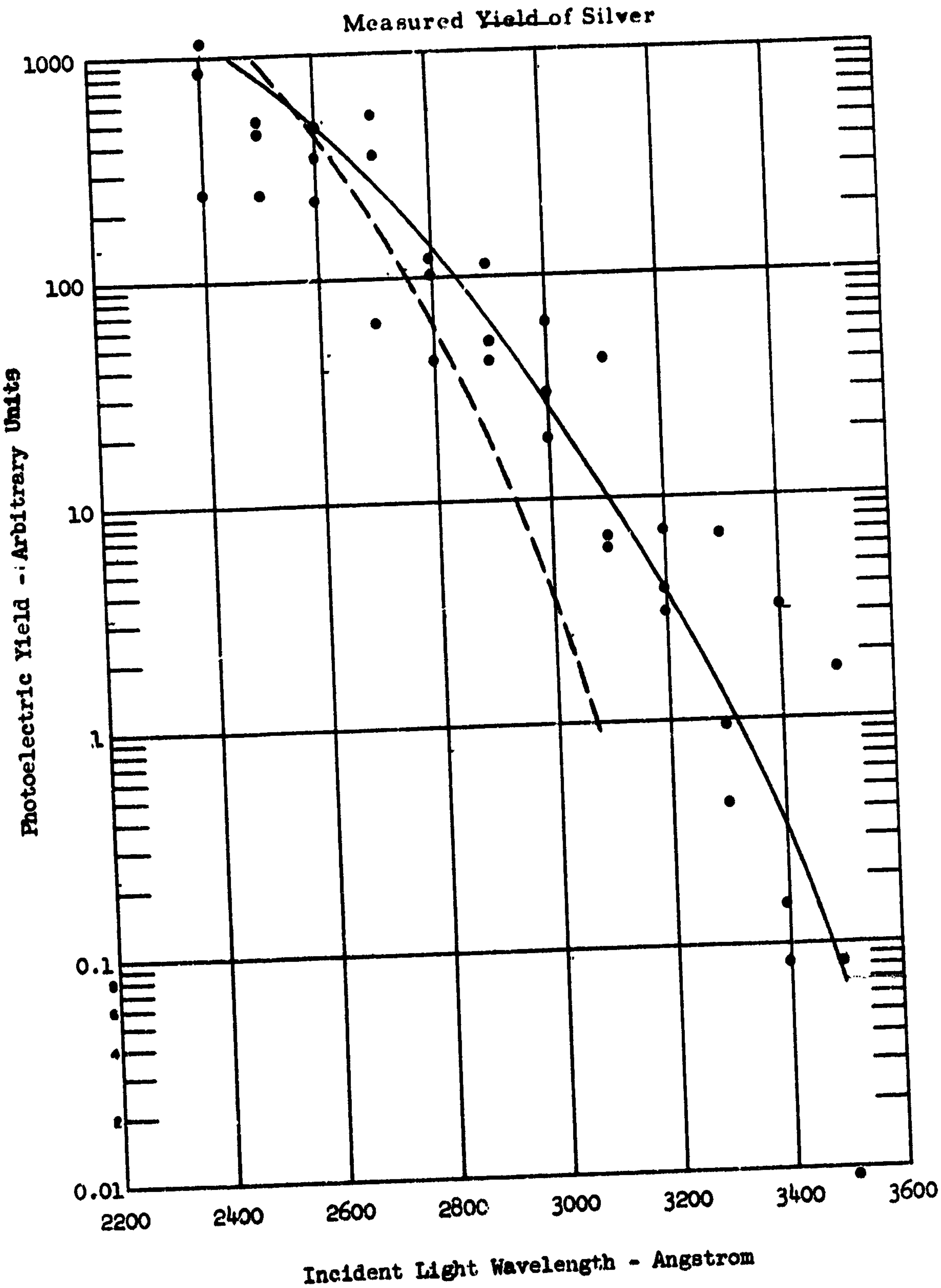
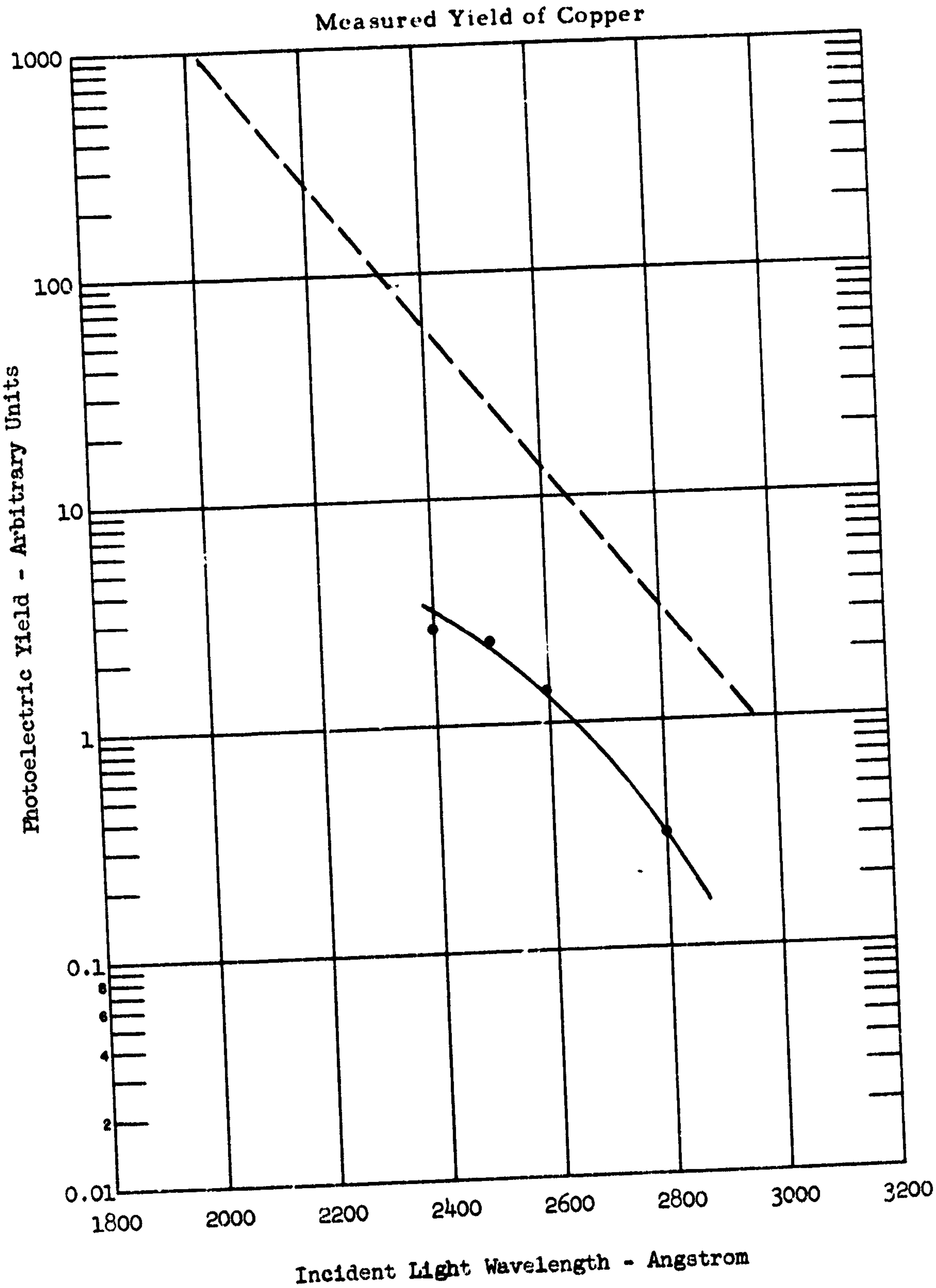

Measured Yield of Silver
1000
100
10
1
0.1
0.01
2200
2400
2600
2800
3000
3200
3400
3600
Photoelectric Yield - Arbitrary Units
Incident Light Wavelength - Angstrom

Figure 17



Measured Yield of Copper
1000
100
10
1
0.1
8
6
4
2
0.01
1800
2000
2200
2400
2600
2800
3000
3200
Photoelectric Yield - Arbitrary Units
Incident Light Wavelength - Angstrom

Figure 18

Measured Yield of Tantalum

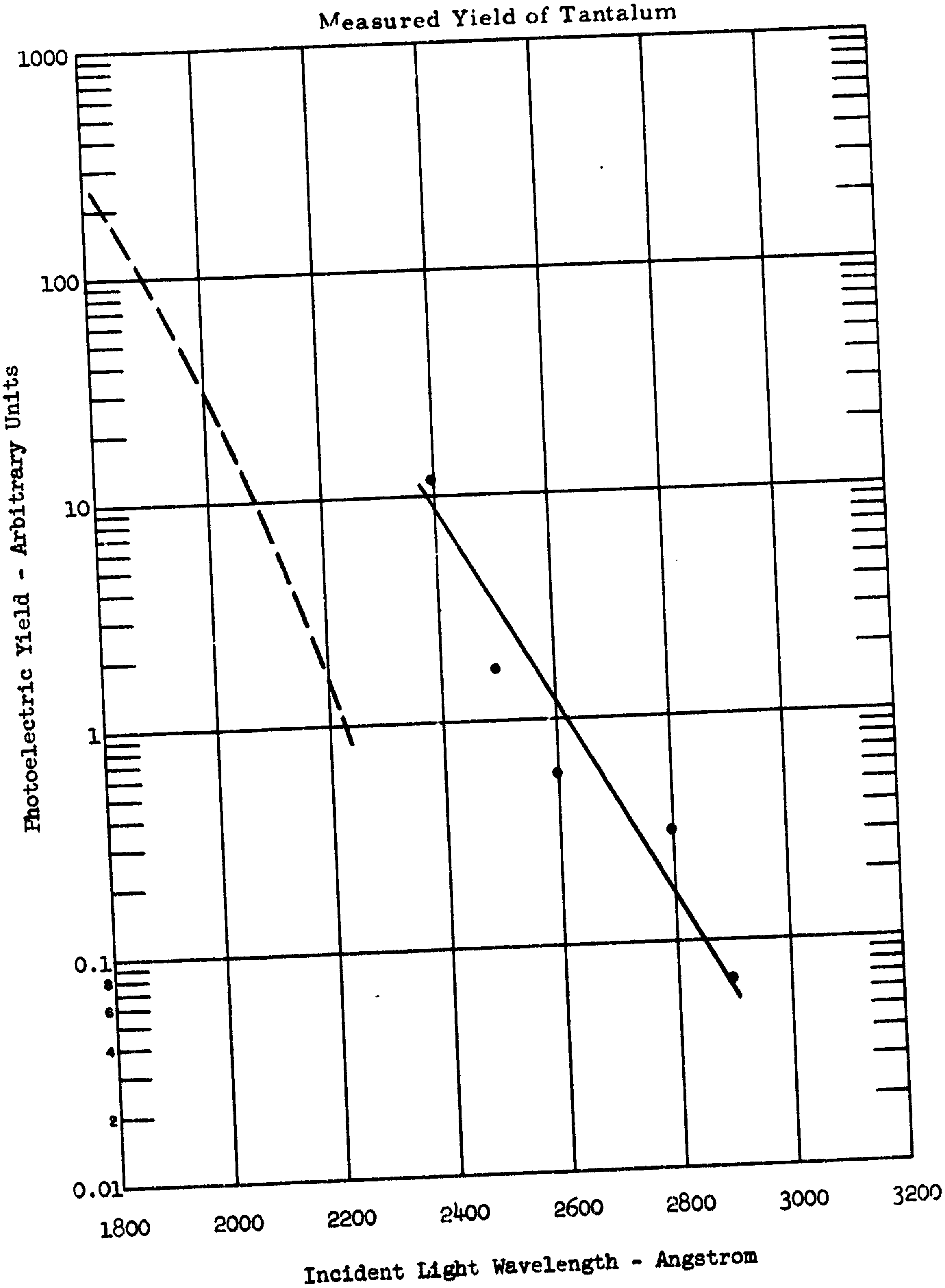


Figure 19

Measured Yield of Tungsten

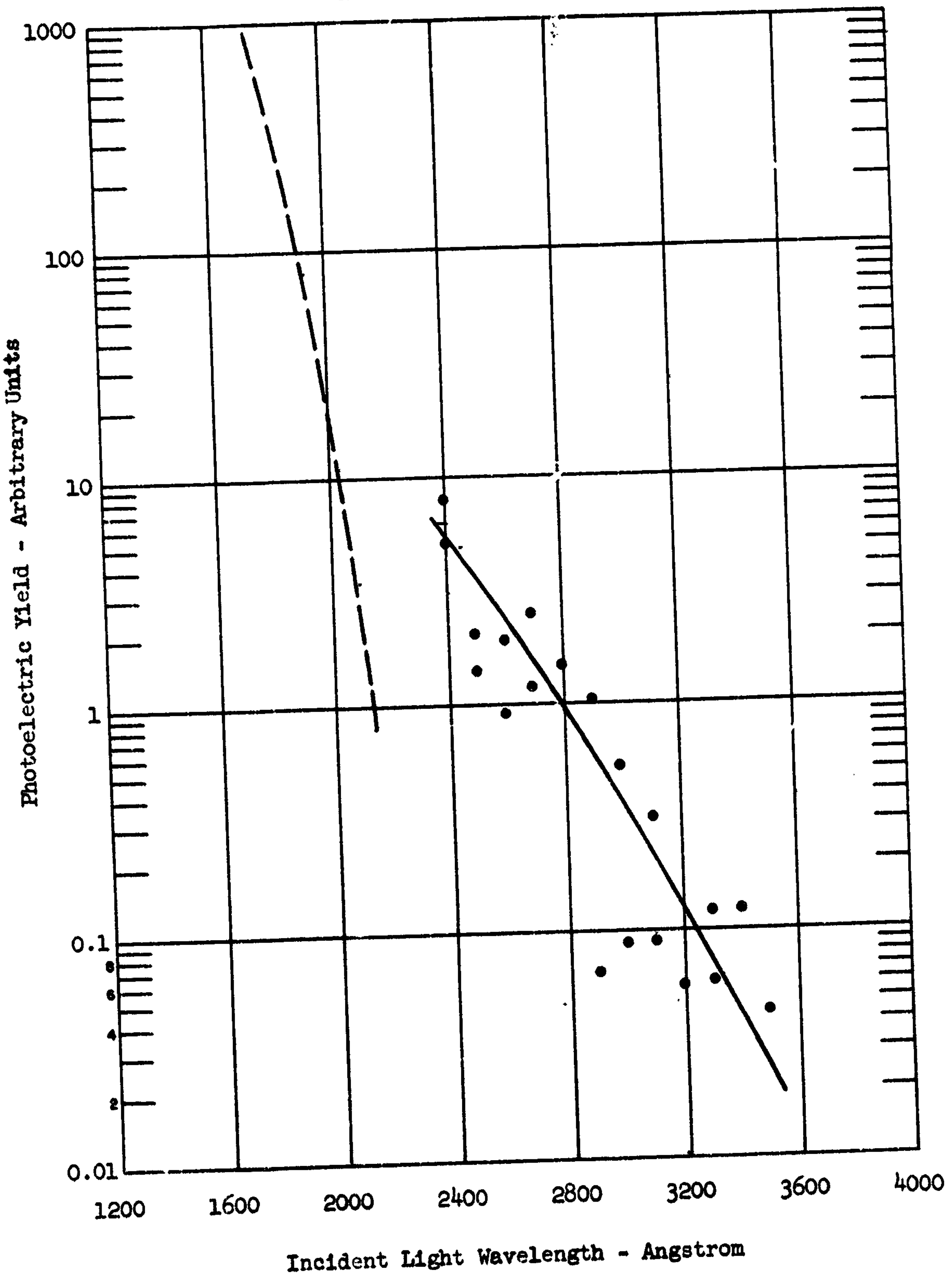


Figure 20

Measured Yield of Zinc

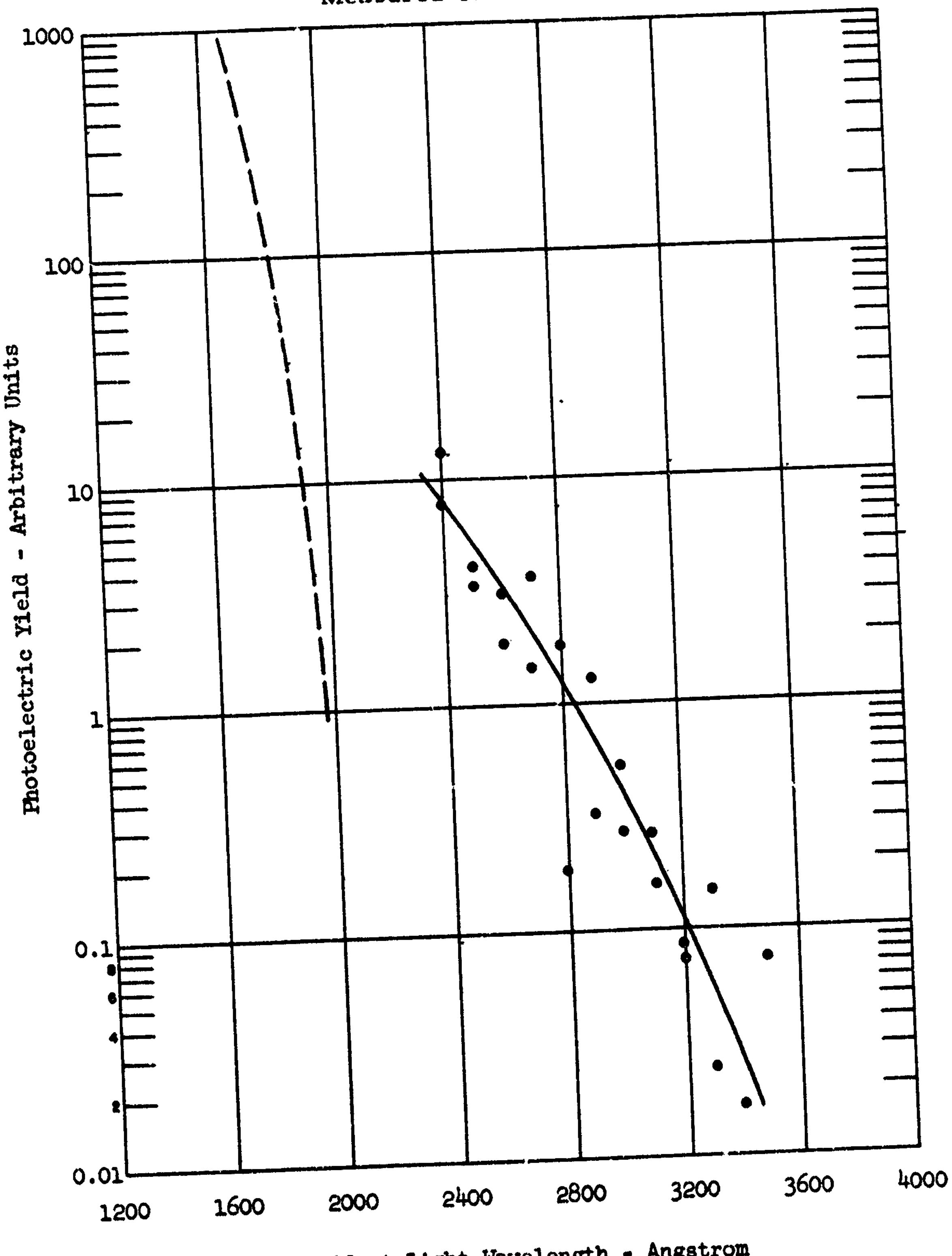


Figure 21

Measured Yield of Copper-Beryllium

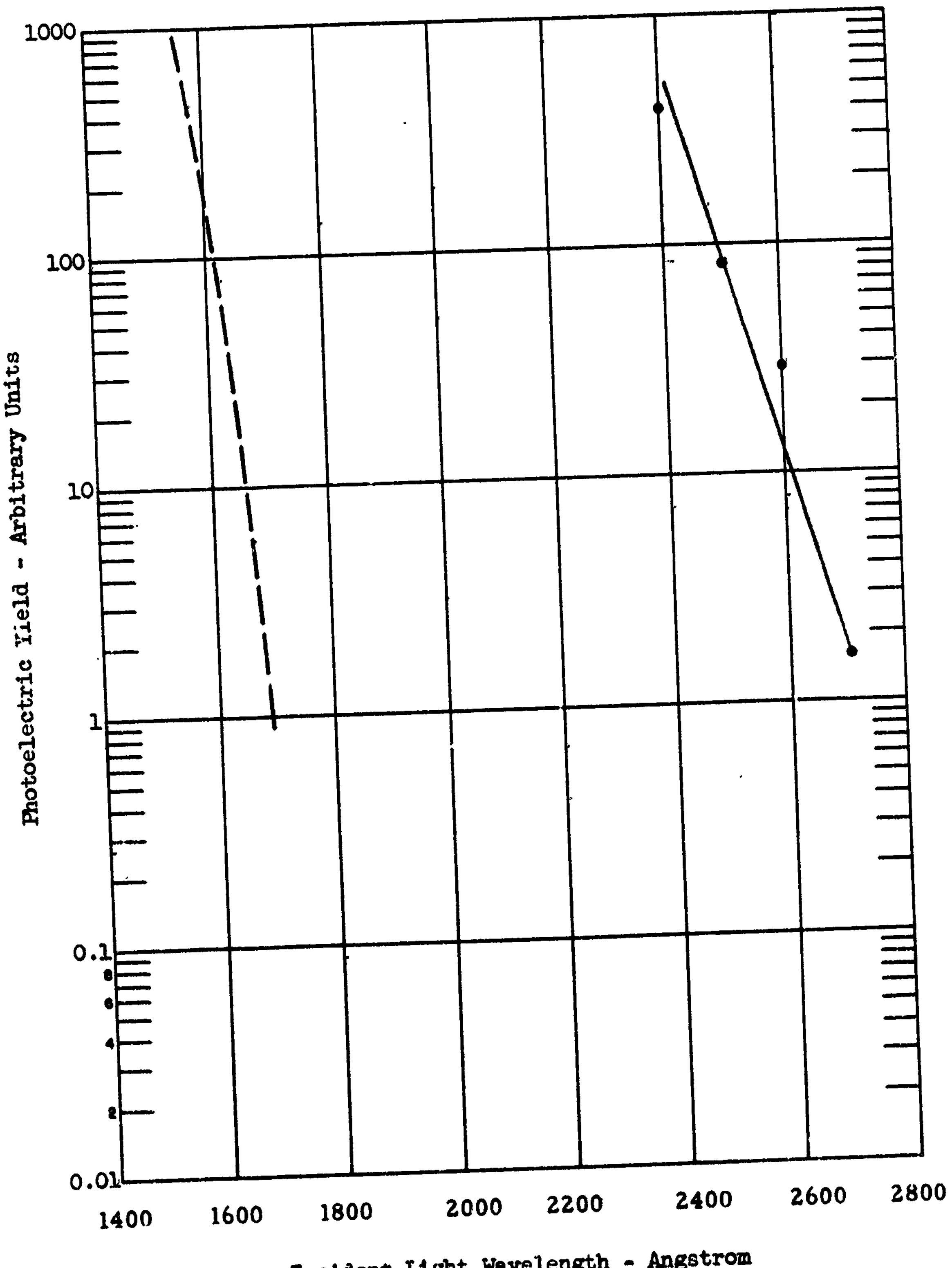


Figure 22

Measured Yield of Carbon

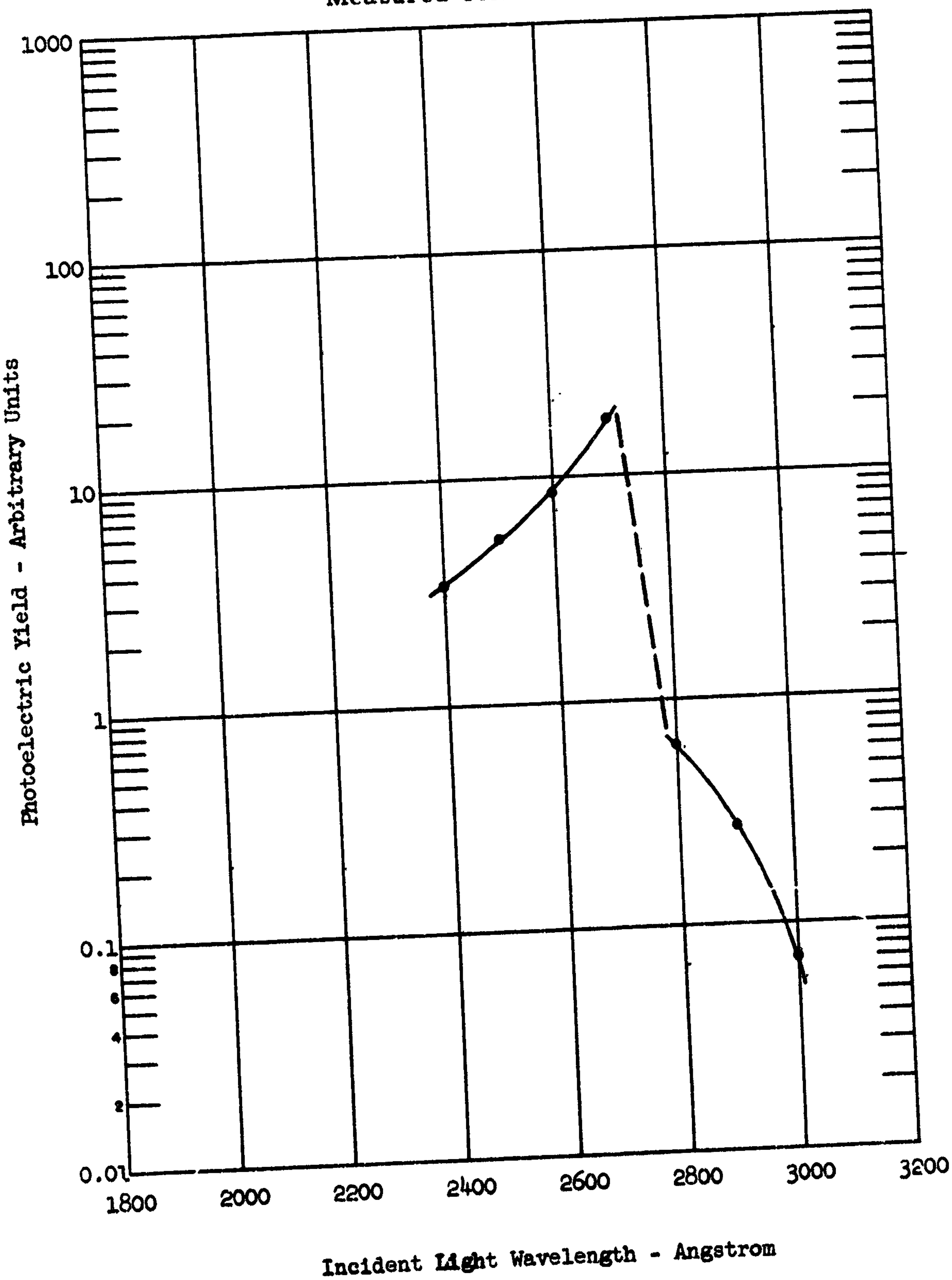


Figure 23

TABLE III

TEST MATERIALS - PHASE IV

SILVER

COPPER-BERYLLIUM

PHOSPHOR BRONZE

ALUMINUM BRONZE

GLASS (GOLD COATINGS 25, 50, 75, 150,
300, and 600 Å THICK)

STAINLESS STEEL, TYPE 304

GRAPHITE

Phosphor bronze, aluminum bronze, and type 304 stainless steel alloys were chosen as typical or potential space craft probe materials. The results of these measurements show that, relative to gold or silver, these alloys have very low yields and total solar emissions. The experimental values for yield are shown in Figures 24-26.

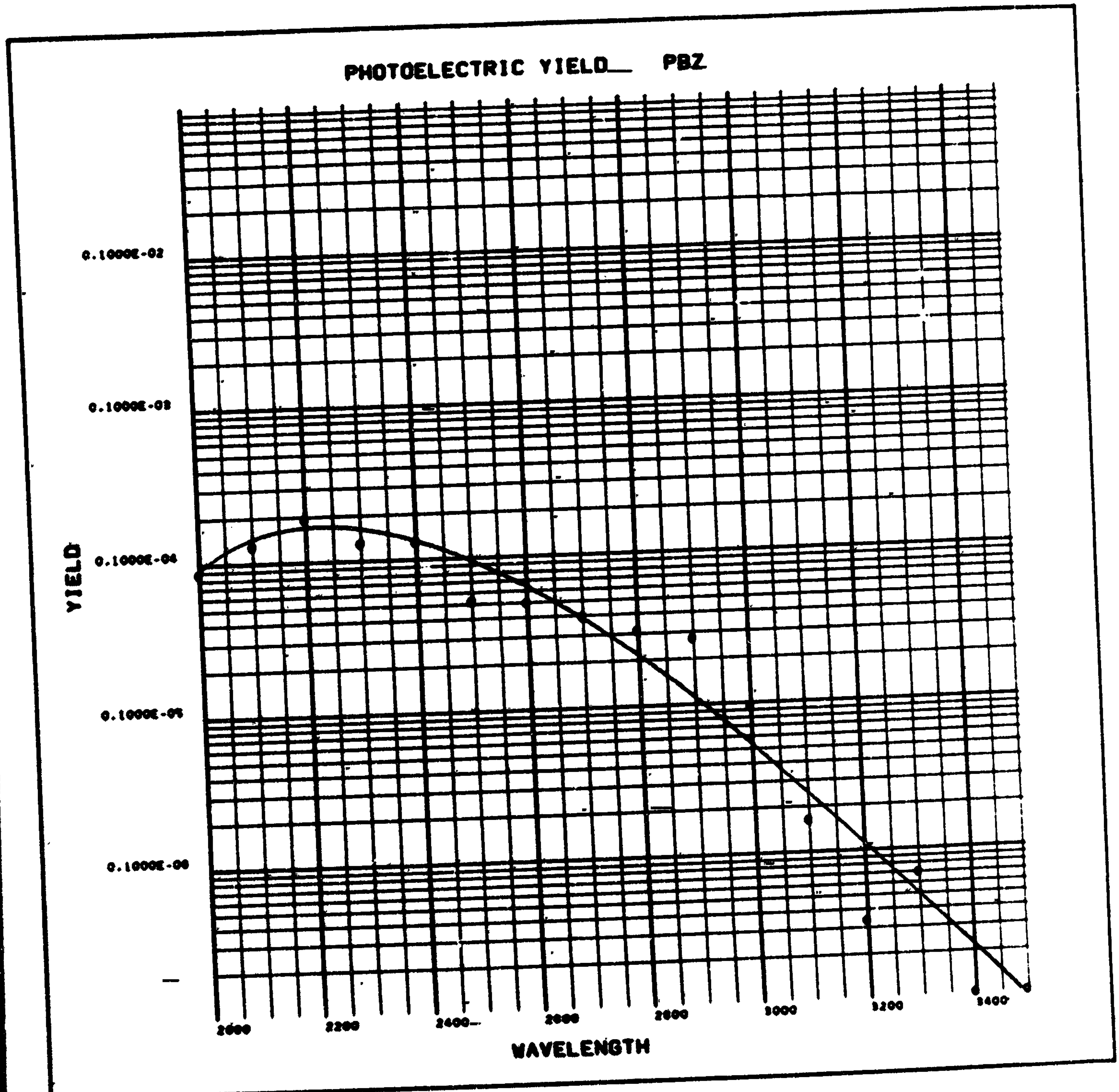
Measurements of emission from copper-beryllium and silver samples were repeated in Phase IV. This was done to allow correlations to be made between all of the Phase IV data and the earlier results. In normalizing the new data the yield of silver at 2500 Å has been set equal to 8.3×10^{-5} electrons per photon, the value reported in Phase III.

The scaling factor for silver at 2500 Å was then used to correct the yields for each of the other samples in the test run. For completeness the yield curves for silver and beryllium-copper are presented in Figures 27-28.

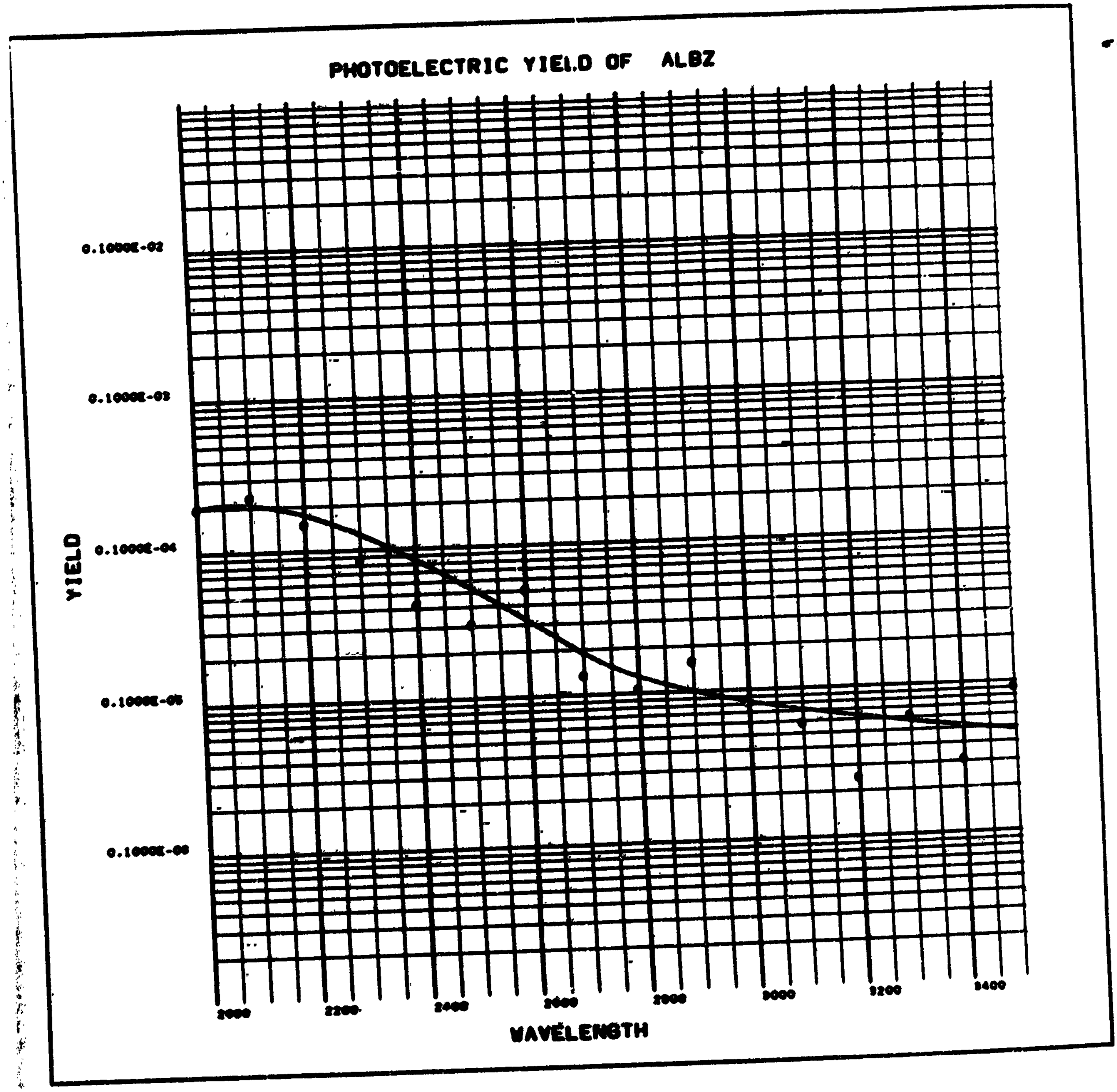
Carbon (graphite) paint samples were included in the Phase III study. However, it has been subsequently learned that this type of sample does exhibit an aging effect in air. For this reason graphite measurements have been repeated in Phase IV. Particular attention was paid to the handling of these samples. After preparation at GSFC the paint samples were sealed in tubes which had been flushed with dry nitrogen. Upon receipt of the samples at Avco, transfer was made to the vacuum chamber and the measurements commenced. Less than one week elapsed between the sample preparation and the first set of measurements. Figure 29 shows the yield data for graphite paint as measured in Phase IV.

A new technique was proposed for the measurement of the photoemission of dielectrics. The emission of a thick layer of gold on a glass substrate is easily measured. It was postulated that the extrapolation to zero thickness of emission measurements on successively thinner gold films would give a measure of the emission of the uncoated glass. This procedure has been followed using evaporated films of gold between 600 and 25 Angstrom thick. Four samples of each of six thicknesses were measured and each measurement was repeated three or four times. Thus 95 separate yield versus wavelength curves were generated. In the analysis of this body of data the question to be answered was: could a variation in yield be associated with film thickness as proposed in this technique.

The yield data as a function of film thickness has been replotted for three selected wavelengths. In these plots (Figures 30-32) the average value and the extrema of the measured and normalized yield values are shown. Two curves have been drawn in these figures. If these were no dependence on thickness over the thickness range of this experiment, a constant yield value would be found as represented by the straight lines. There would seem, however, to be an indication of an upturn in the results at thicknesses less than 75 Angstrom. A curve has been drawn to reflect this observation. This trend can be seen in the integrated solar emission which will be discussed in a later section.

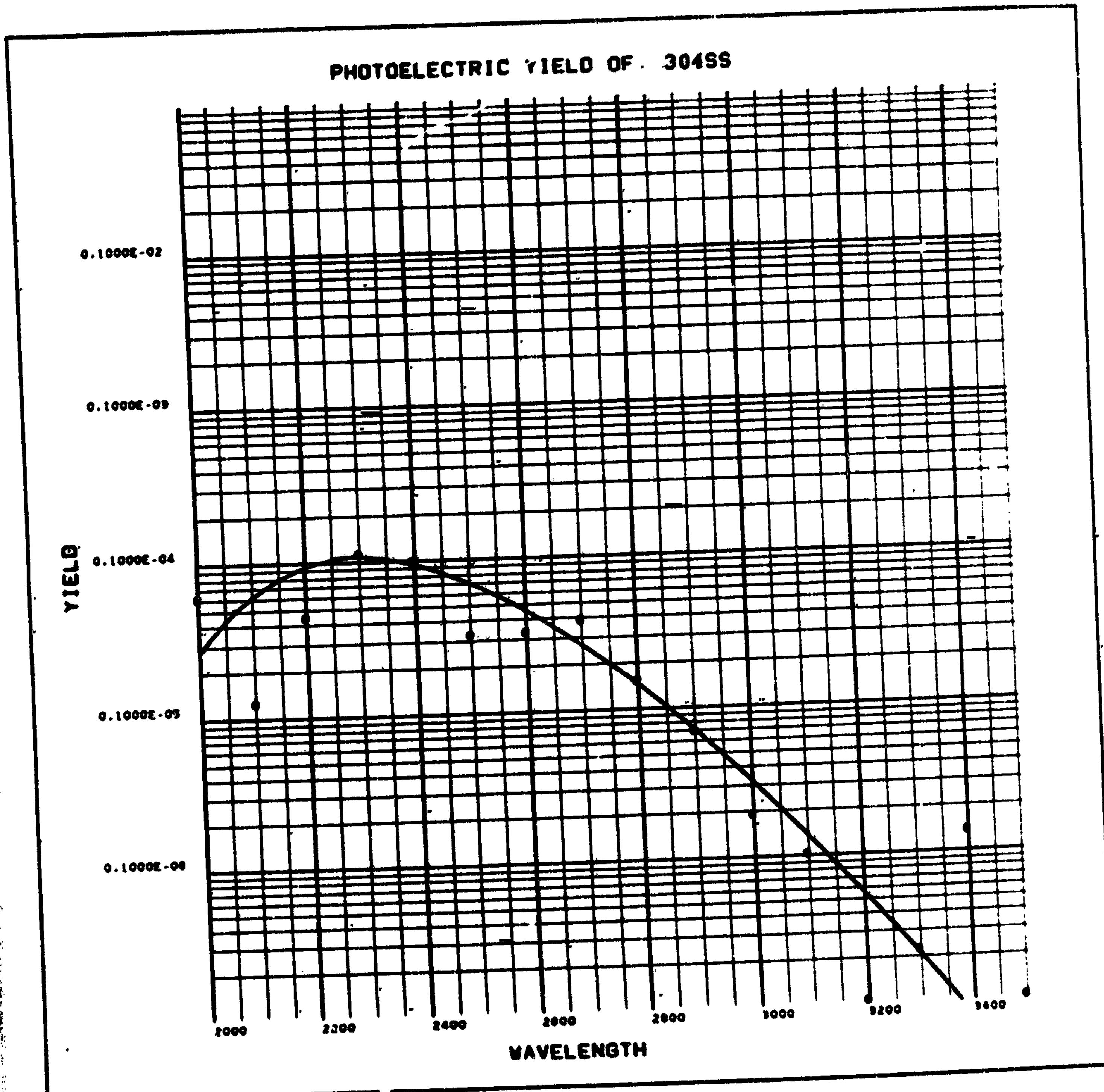


PHOSPHOR BRONZE
FIGURE 24



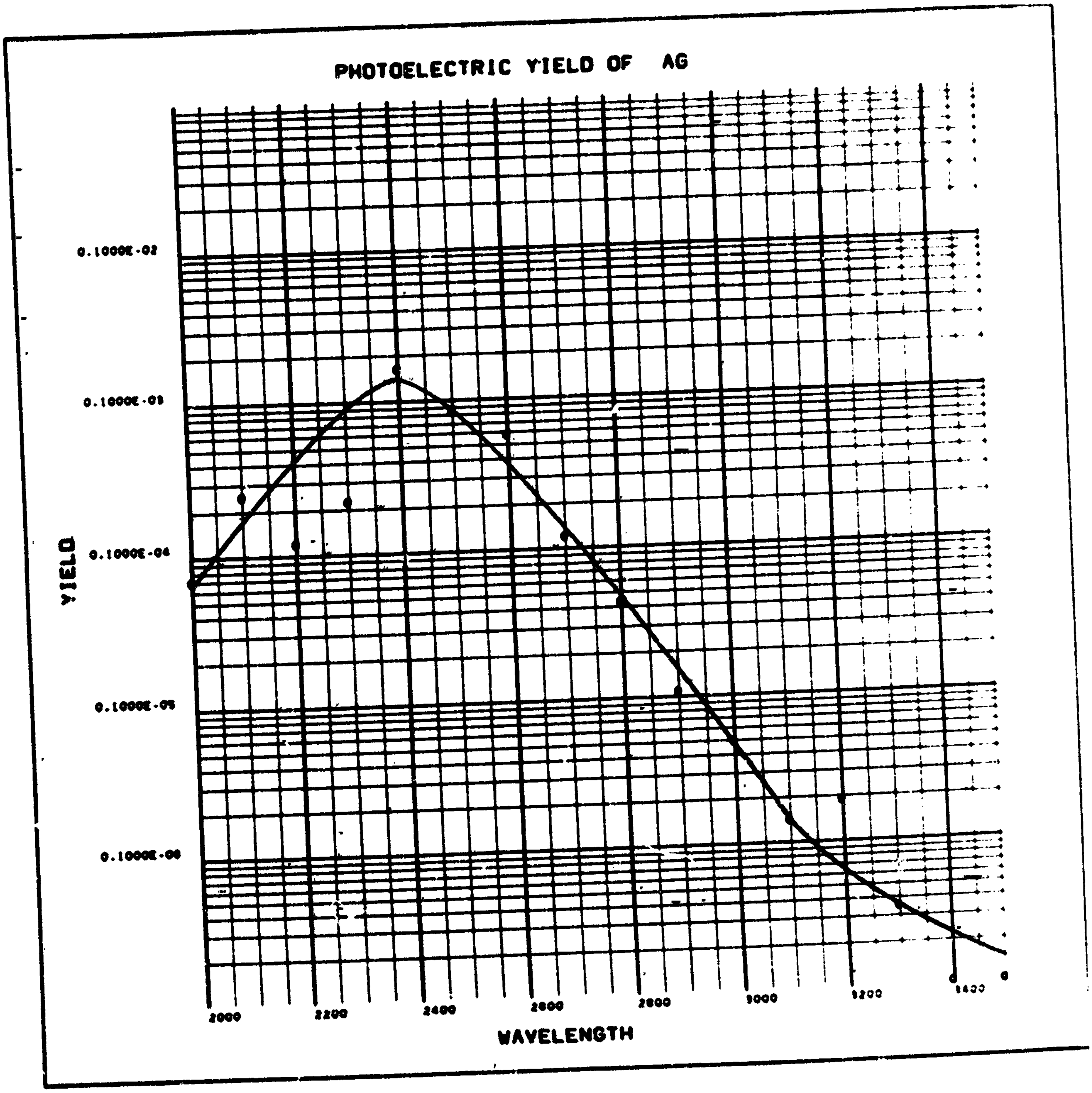
ALUMINUM BRONZE

FIGURE 25



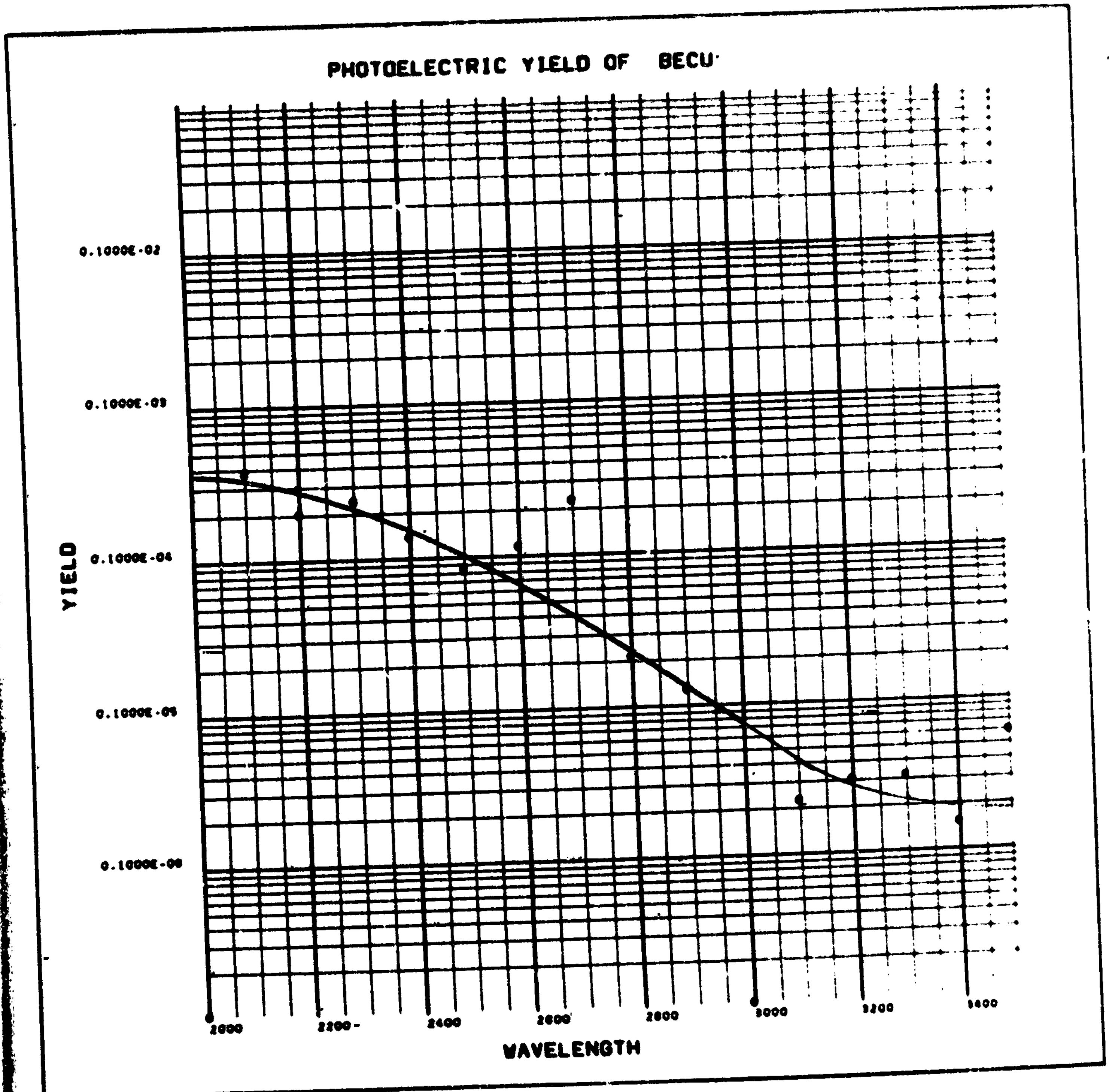
STAINLESS STEEL, TYPE 304

FIGURE 26



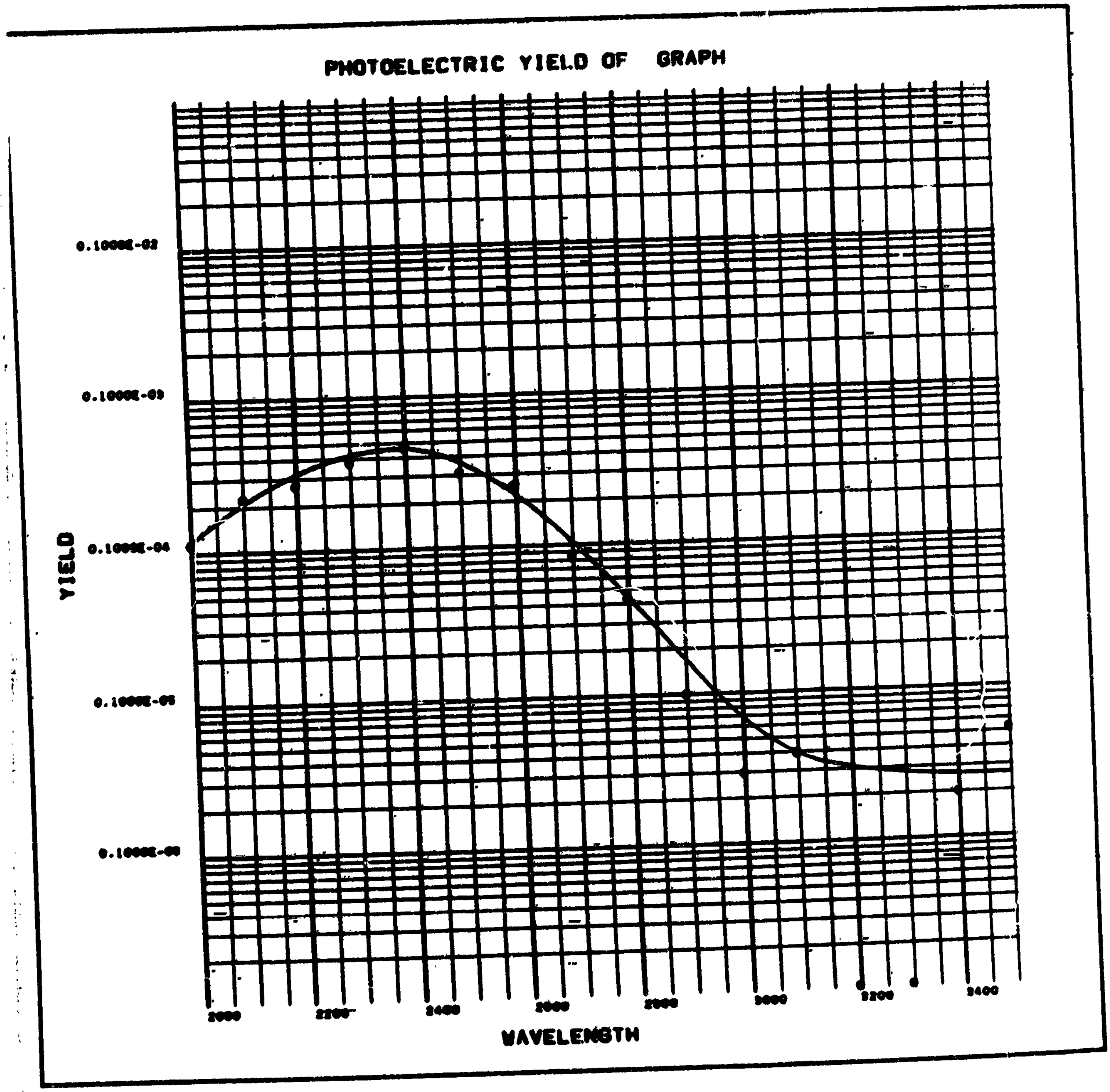
SILVER

FIGURE 27



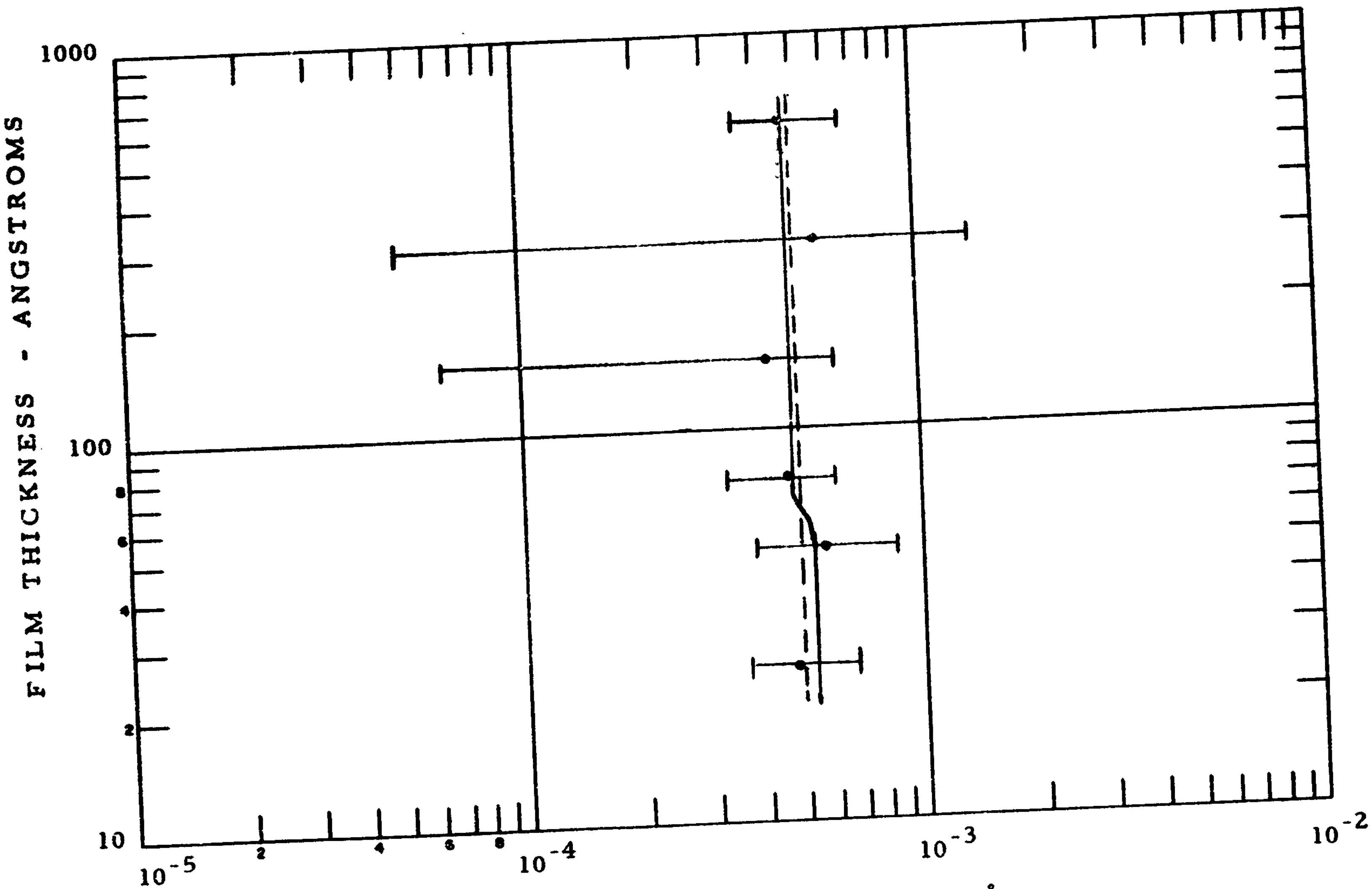
BERYLLIUM - COPPER

FIGURE 28

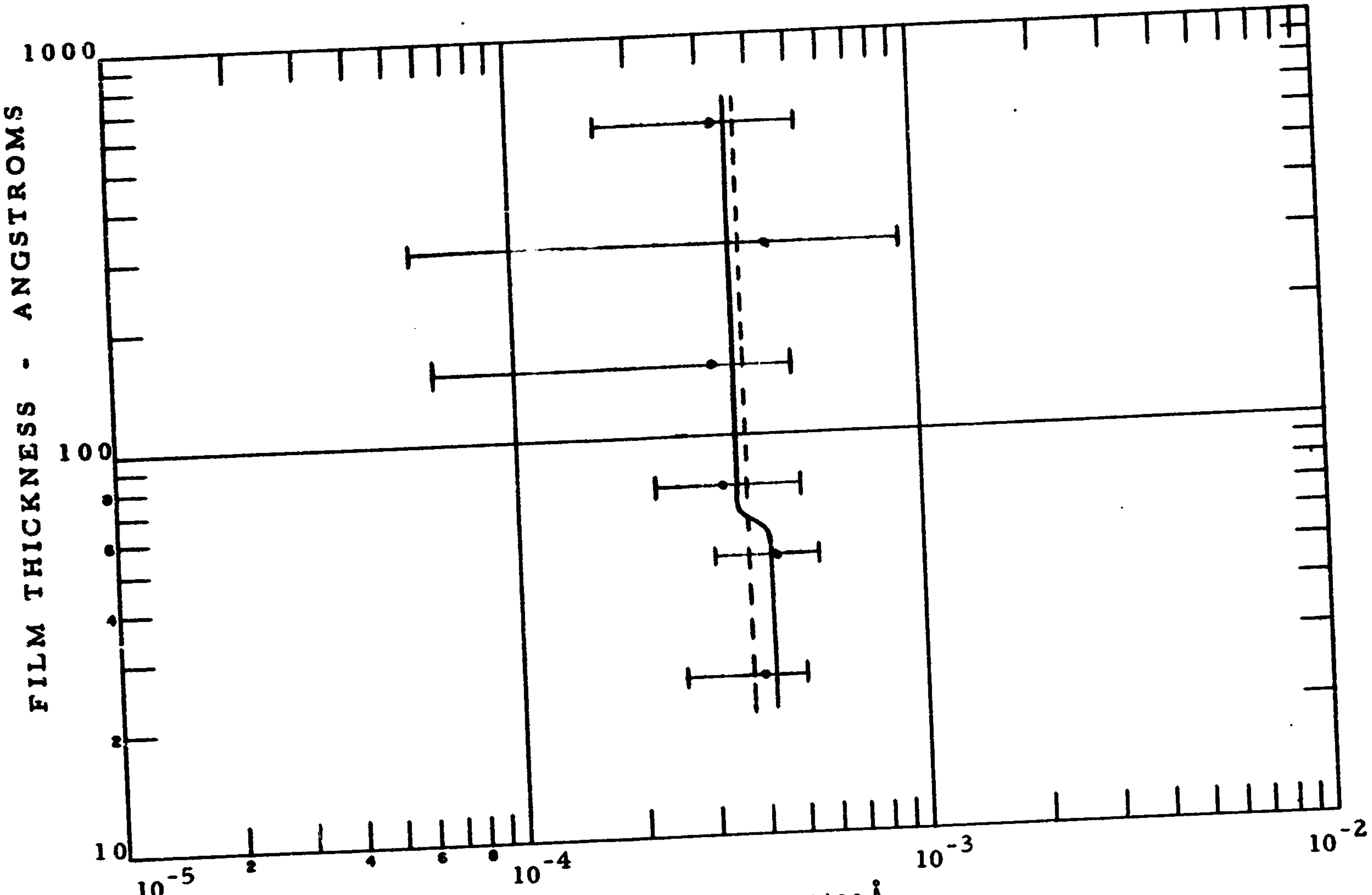


GRAPHITE

FIGURE 29



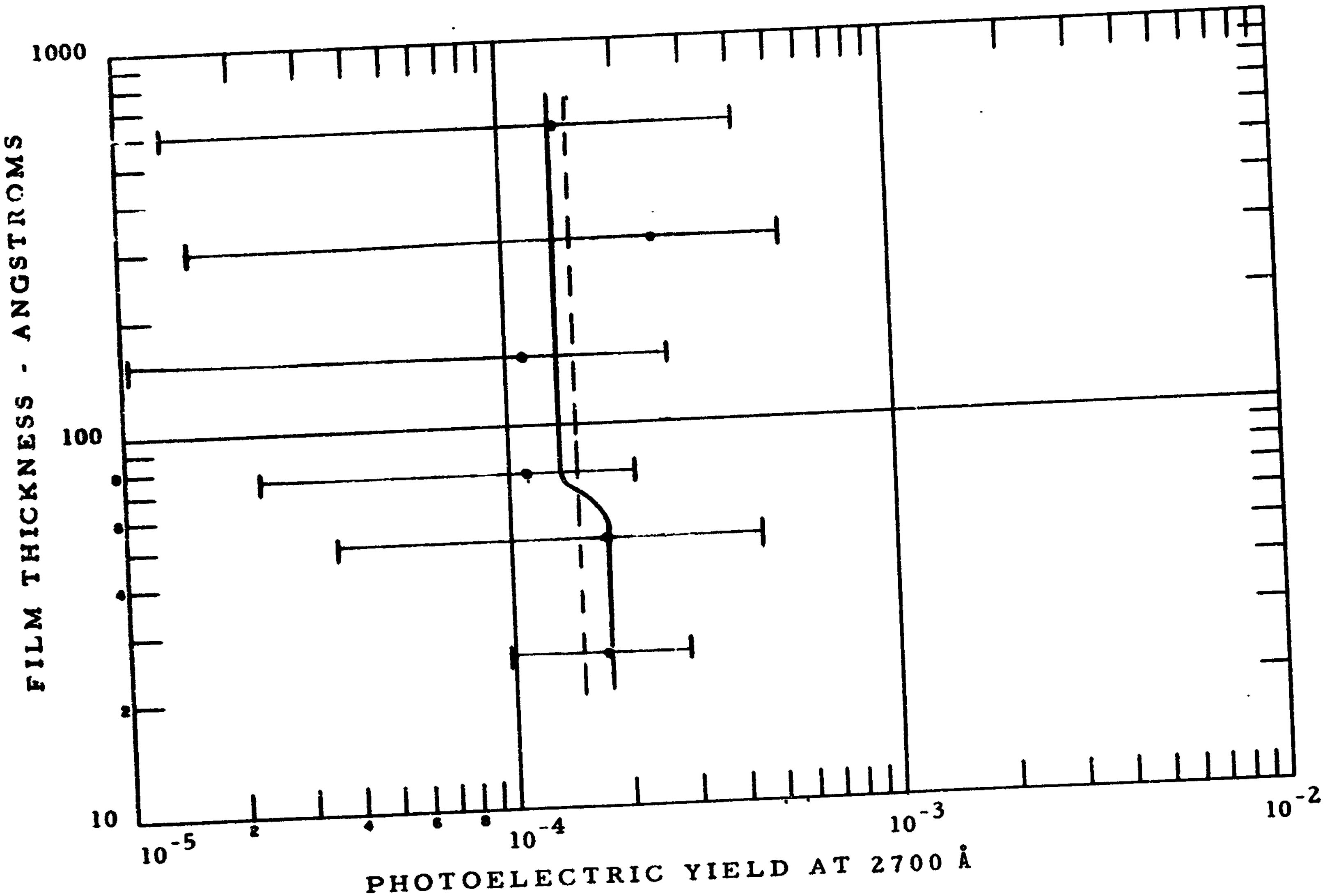
PHOTOELECTRIC YIELD AT 2500Å
GOLD FILMS
FIGURE 30



PHOTOELECTRIC YIELD AT 2600 Å

GOLD FILMS

FIGURE 31



GOLD FILMS

FIGURE 32

IV. MATERIALS EVALUATION

In the previous sections we have presented yield data measured at Avco and elsewhere for a variety of materials. These data suggest which materials would be preferred for the fabrication of electric field probes. The emission performance under exposure to solar radiation, however, is a better figure of merit. This value has been calculated and is the subject of this section.

A plot of the solar spectral irradiance [12] is reproduced in Figure 33. The large fluctuations in the x-ray region can be seen together with the line structure which culminates with the Lyman-α line at 1215 Å. One may convert this plot of energy density per unit wavelength to a plot of photon flux density per unit wavelength. This type of plot is shown in Figure 34. The data are taken from Reference 13.

Now if we multiply a yield curve of the type drawn in Figure 1 by the solar photon flux spectrum (Figur[illegible]), point-by-point, we will obtain a plot of photoemitted electron flux per unit wavelength versus wavelength. Integration of this curve over the entire wavelength regime gives the total number of photoelectrons emitted per square centimeter per second. This is exactly the characteristic desired for the comparative evaluation of materials for the field probe application.

A computer code has been written to carry out the calculation described above. The code is listed in Appendix I. It is written in a dialect of FORTRAN peculiar to the time-share system used for this calculation. (For Phase IV it was necessary to rewrite this program for the IBM 360/75). The minor differences in syntax should not prevent the reader from following the calculation method.

Table IV presents the results of the integration of Phase III data. The value of this method can be seen if one compares platinum and gold. Although the yield curves are identical in the region of high yield (up to about 1200 Å), the total emission of platinum is three times greater than that of gold. This is due to variations in yield in a region where the yield is two to three decades lower than the maximum value. It is inadequate, therefore, to look only at the peak of yield curves when evaluating materials. It is also insufficient to measure the total emission experimentally using a light source spectrally different from the sun.

The detailed results of the calculation are reproduced in Appendix II. In those tabulations the columns are:

1) Wavelength in Angstroms
2) Yield at that wavelength in electrons/photon
3) The emission in the band defined by the wavelength of the given line and that of the next line (electrons cm^{-2} sec^{-1}).

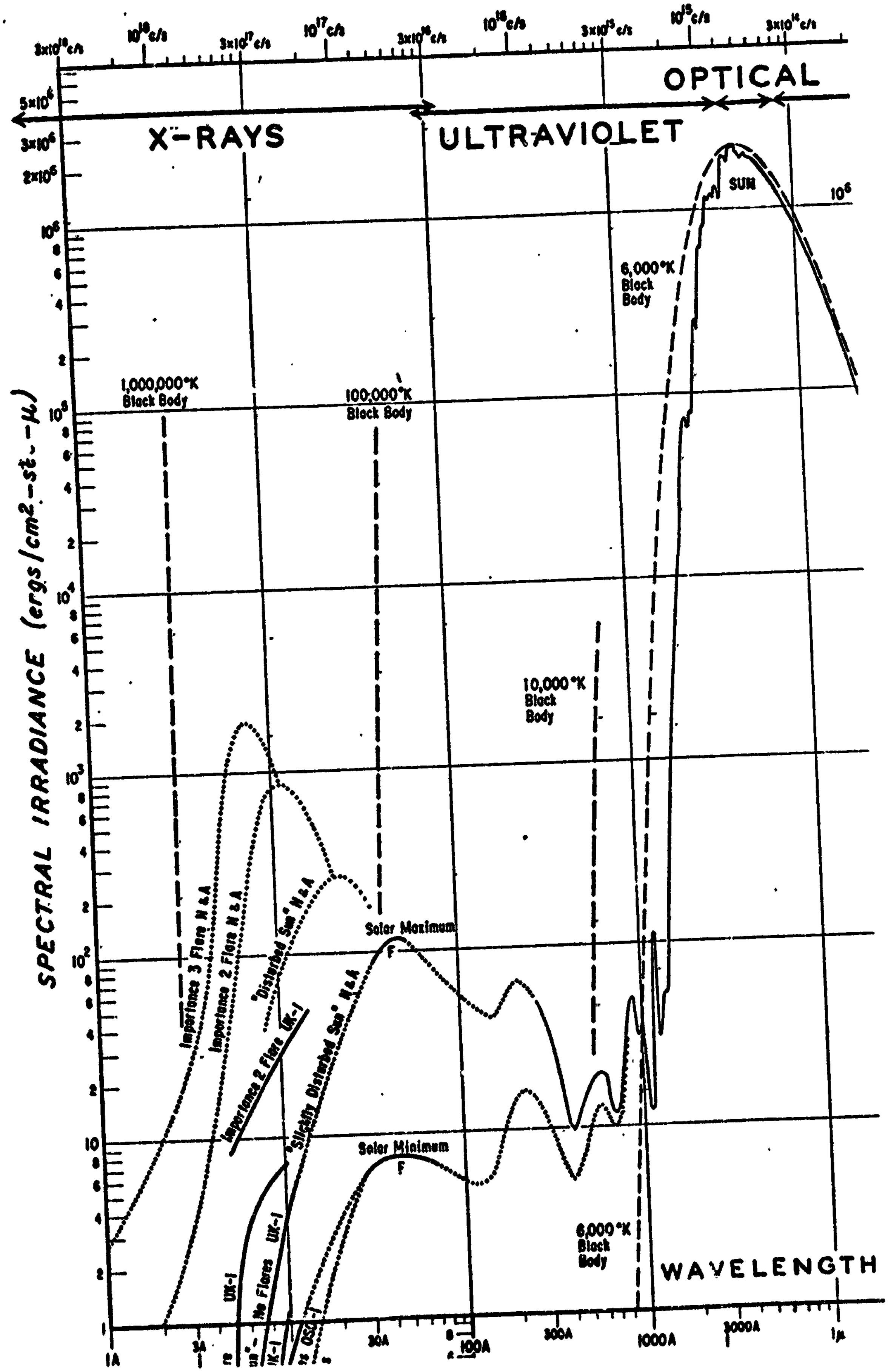


FIGURE 33 SOLAR SPECTRAL IRRADIANCE

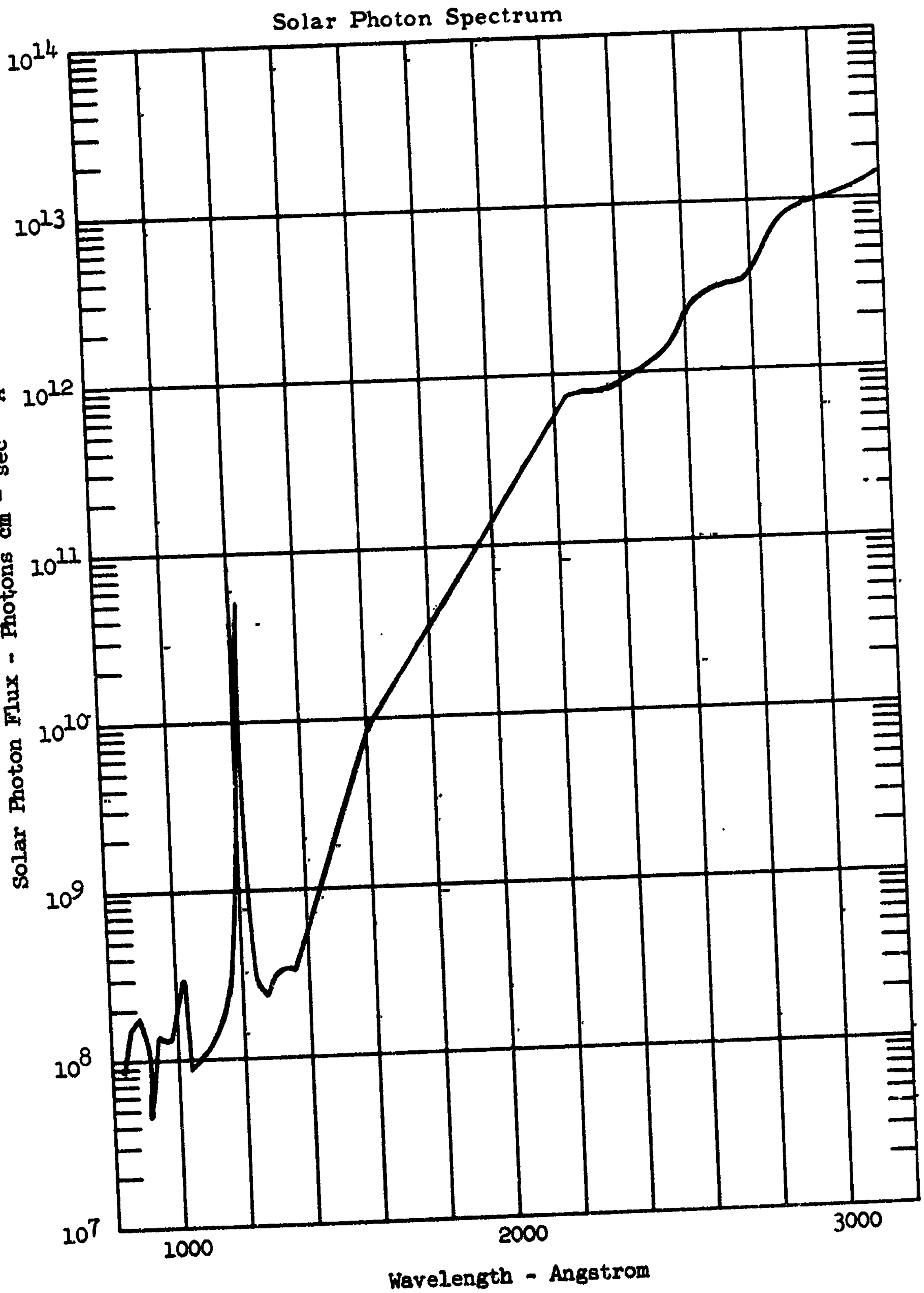

Solar Photon Spectrum
10^14
10^13
10^12
10^11
10^10
10^9
10^8
10^7
Solar Photon Flux - Photons cm^-2 sec^-1 A^-1
1000
2000
3000
Wavelength - Angstrom

Figure 34

TABLE IV

TOTAL PHOTOCURRENT - PHASE III

	Electrons cm^{-2} sec^{-1}
Aluminum	1.62×10^{10}
Cadmium	1.05×10^{10}
Copper	2.33×10^{10}
Copper-Beryllium	6.89×10^{9}
Gold	4.51×10^{10}
Nickel	1.02×10^{10}
Platinum	1.44×10^{11}
Silver	1.13×10^{11}
Tantalum	1.50×10^{10}
Tungsten	1.08×10^{10}
Zinc	9.63×10^{9}

4) The emission per Angstrom of wavelength
5) The total emission, i. e., a running total of column 3.

A slightly different procedure was used in the integration of the Phase IV results than had been used previously. In Phase-III the input values for absolute yield were taken from published sources and extended well into the vacuum ultraviolet. In Phase IV the range of integration was between 2000 and 3500 Angstroms only. The input yield data used were the values normalized with respect to silver at 2500 Å as previously discussed. One should not, therefore, make direct comparisons between the results given in Table IV and the Phase IV results which are listed in Table V.

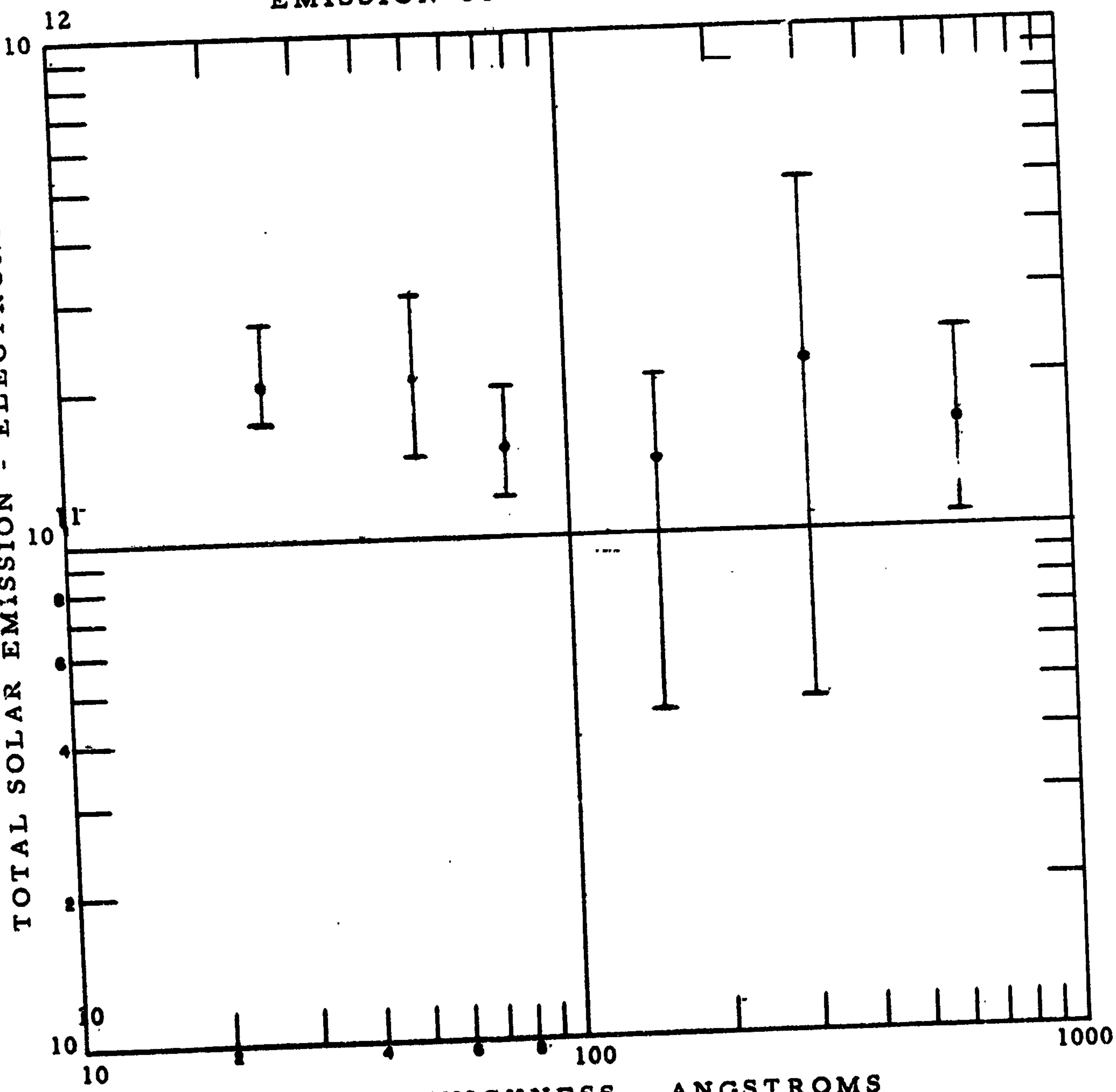
The gold-on-glass yield data were also used in the solar integration analysis. The average total emission due to solar radiation over the 2000-3500 Å band for each of the six gold film thicknesses has been plotted in Figure 35. The extrema in these calculated values are shown. The rise noted in yield values for the thinner films is reflected in this figure.

TABLE V

TOTAL PHOTOCURRENT - PHASE IV

Aluminum Bronze	8.15×10^{9}
Copper - Beryllium	5.80×10^{9}
Graphite	1.56×10^{10}
Phosphor Bronze	6.17×10^{9}
Silver	3.46×10^{10}
Stainless Steel, type 304	6.39×10^{9}

EMISSION OF GOLD FILMS



FILM THICKNESS - ANGSTROMS

FIGURE 35

V. CONCLUSIONS

In this report we have discussed the necessity of using the absolute spectral photoelectric yield instead of the total photoelectric sensitivity when comparing materials. It has been pointed out that the selection of materials for applications such as the measurement of the electric field by a two-probe method should be based on the total emitted current in the operational environment. For a space measurement this means that the expression

$$I = Y(\lambda)\ F(\lambda)\ d\lambda$$

where

$Y(\lambda)$ is the yield

$F(\lambda)$ is the solar photon flux

should be evaluated for each candidate material and the resulting current densities, I, should be used as the basis for selection. This has been done and the results given in Table IV and V. On the basis of these results, it is clear that uncoated copper-beryllium is a preferred material. Silver (or silver coated copper-beryllium) has one of the highest photoemissions when exposed to solar radiation.

Further insight into the importance of the form of the solar spectrum is gained from a plot of the cumulative emission up to a wavelength value as a function of that value. Such a plot is given for cadmium and platinum in Figure 36. A sharp increase in this function is seen for both materials due to the Lyman-α line at 1215 Å. For cadmium this is the principal source of the emission. For platinum with a yield curve extending to longer wavelengths, however, the increase is principally in the 1800-2400 Å band.

In the earlier discussions of the absolute yield data, it was pointed out that contamination in a sample could contribute to significant changes in the yield value. Zinc (Figure 10) was cited as an example. A review of the relative yield measurements, which have been made as part of this program, reveals shifts in the curves relative to the extrapolations of the absolute yield data which might be explained in similar terms (e.g., surface contamination). Copper-beryllium is a case of particular interest. While the absolute yield data of Cairns and Samson (Figure 11) suggests a sharp cut-off of emission at 1700 Å, our normalized data indicates a yield of about 10^{-6} electrons per photon at 2500 Å. If these data were used in the integration with the solar flux, a vastly different total emission would be found.

A detailed study of the effects of various surface preparation procedures would clarify this uncertainty. It is suggested that these surface

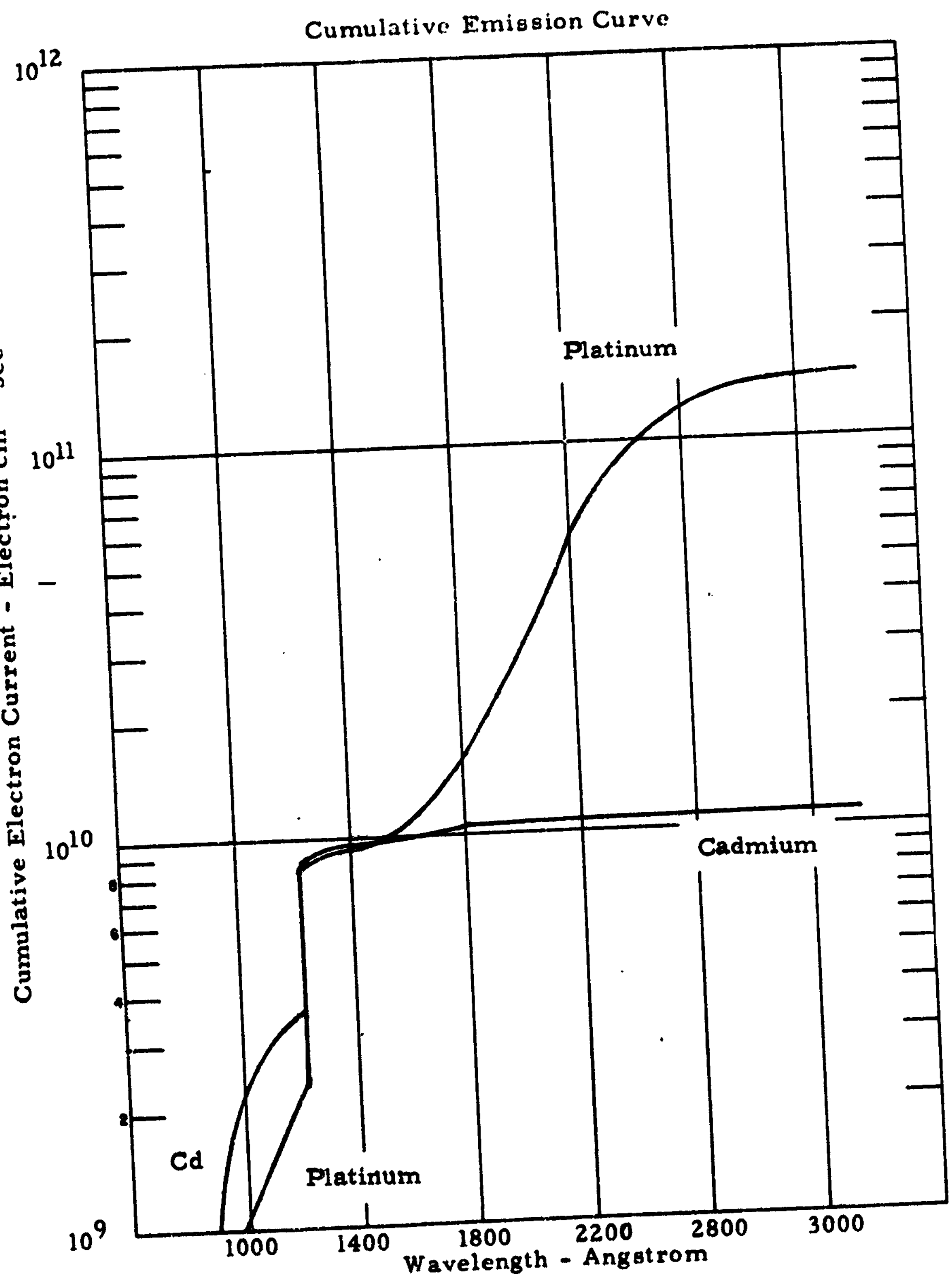

Cumulative Emission Curve
10^{12}
10^{11}
10^{10}
10^{9}
8
6
4
2
Cumulative Electron Current - Electron cm^{-2} sec^{-1}
Platinum
Cadmium
Cd
Platinum
1000
1400
1800
2200
2800
3000
Wavelength - Angstrom

Figure 36

effects could be studied satisfactorily in the near ultraviolet region and that useful preparation procedures might be developed.

In Phase IV additional materials were studied experimentally. The alloys (aluminum bronze, phosphor bronze, and stainless steel) were found to be low emitters as copper-beryllium had been reported earlier. More complete graphite data were obtained in Phase IV than in Phase II. The emission of graphite falls in an intermediate range. The attempt to measure the photoelectric yield of a dielectric such as glass has been described. A yield increase of about 20 percent was seen at a thickness between 75 and 50 Å. Before one can state that the technique is effective additional tests should be conducted.

VI. REFERENCES

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APPENDIX I

A listing of the computer code which was written to calculate the total photoemission is reproduced on the following page. It is written in a dialect of FORTRAN peculiar to the time-share system used for this calculation. The minor differences in syntax should not prevent the reader from following the calculation method.

COMPUTER CODE

```
DIMENSION S(70),F(70),W(50),Y(50)
OPEN(3,INPUT,/SUN/)
11 DO 12 I=1,70
READ(3,...) S(I),F(I)
IF (F(I)) 14,12,12
12 C'E
14 IS=I-1
CLOSE(3)
15 WRITE (1,(9HMATERIAL:,Z))
READ (1,(A1)) NAL
DO 20 I=1,50
ACCEPT W(I),Y(I)
IF (W(I)) 21,21,20
20 C'E
21 IY=I-1
TOT=0.0
J=1
DO 25 K=2,IS
IF(S(K)-W(1)) 25,25,26
25 C'E
D'Y $NO OVERLAP$
GO TO 15
26 D'Y $INTEGRATION STARTS AT  $, S(K)
WRITE (1,50)
27 YY=10**((S(K)-W(J))/(W(J+1)-W(J))*(ALOG10(Y(J+1))-ALOG10(Y(J)))+
        ALOG10(Y(J)))
A=F(K)*YY
TOT=TOT+A
AA=A/(S(K+1)-S(K))
WRITE (1,51) S(K),YY,A,AA,TOT
K=K+1
IF (K-IS) 28,28,29
28 IF (S(K)-W(J+1)) 27 ,27,29
29 IF (W(J+1)) 99,99,30
30 J=J+1
GO TO 28
99 D'Y $INTEGRATION COMPLETE$
GO TO 15
50 FORMAT (5H WAVE,3X,5HYIELD,6X,8HEMM/BAND,7X,6HEMM/A ,8X,5HTOTAL)
51 FORMAT (F6.0,F8.4,3E14.5)
END
```

APPENDIX II

The detailed results of the calculation are reproduced in this appendix. In the tabulations the columns are:

1) Wavelength in Angstroms.

2) Yield at that wavelength in electrons/photon.

3) The emission in the band defined by the wavelength of the given line and that of the next line (electrons cm^{-2} sec^{-1}).

4) Emission per Angstrom of wavelength.

5) The total emission, i. e., a running total of column 3.

Data are presented for the following materials:

Aluminum, Cadmium, Copper, Copper-beryllium, Gold,

Nickel, Platinum, Silver, Tantalum, Tungsten, and Zinc.

ALUMINUM

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
860.	0.1509	.63366E+09	.21122E+08	.63366E+09
890.	0.1381	.55258E+09	.26313E+08	.11862E+10
911.	0.1299	.16235E+09	.18039E+08	.13486E+10
920.	0.1265	.18974E+09	.63246E+07	.15383E+10
950.	0.1158	.63702E+09	.15925E+08	.21753E+10
990.	0.1030	.51491E+09	.13916E+08	.26902E+10
1027.	0.0898	.35003E+09	.26925E+08	.30403E+10
1040.	0.0852	.40043E+09	.80086E+07	.34407E+10
1090.	0.0697	.30685E+09	.76711E+07	.37475E+10
1130.	0.0565	.46910E+09	.93820E+07	.42166E+10
1180.	0.0426	.23410E+09	.11705E+08	.44507E+10
1200.	0.0380	.44460E+09	.29640E+08	.48953E+10
1215.	0.0337	.90938E+10	.18188E+10	.13989E+11
1220.	0.0324	.84118E+09	.15294E+08	.14830E+11
1275.	0.0208	.24528E+09	.49056E+07	.15076E+11
1325.	0.0129	.22796E+09	.45592E+07	.15304E+11
1375.	0.0074	.13527E+09	.27054E+07	.15439E+11
1425.	0.0039	.14598E+09	.29197E+07	.15585E+11
1475.	0.0020	.14297E+09	.28594E+07	.15728E+11
1525.	0.0010	.12930E+09	.25860E+07	.15857E+11
1575.	0.0005	.12547E+09	.25094E+07	.15983E+11
1625.	0.0002	.91773E+08	.18355E+07	.16074E+11
1675.	0.0001	.63174E+08	.12635E+07	.16138E+11
1725.	0.0000	.33313E+08	.66627E+06	.16171E+11
1775.	0.0000	.66807E+07	.26723E+06	.16178E+11
1800.	0.0000	.87500E+07	.17500E+06	.16186E+11
1850.	0.0000	.78282E+06	.15656E+05	.16187E+11

CADMIUM

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
810.	0.1354	.33842E+09	.11281E+08	.33842E+09
840.	0.1224	.24474E+09	.12237E+08	.58316E+09
860.	0.1144	.48051E+09	.16017E+08	.10637E+10
890.	0.1034	.41369E+09	.19699E+08	.14774E+10
911.	0.0947	.11838E+09	.13154E+08	.15957E+10
920.	0.0906	.13588E+09	.45294E+07	.17316E+10
950.	0.0781	.42956E+09	.10739E+08	.21612E+10
990.	0.0641	.32045E+09	.86609E+07	.24816E+10
1027.	0.0533	.20786E+09	.15989E+08	.26895E+10
1040.	0.0499	.23473E+09	.46947E+07	.29242E+10
1090.	0.0389	.17115E+09	.42787E+07	.30954E+10
1130.	0.0308	.25535E+09	.51069E+07	.33507E+10
1180.	0.0226	.12440E+09	.62201E+07	.34751E+10
1200.	0.0200	.23400E+09	.15600E+08	.37091E+10
1215.	0.0180	.48668E+10	.97335E+09	.85759E+10
1220.	0.0174	.45269E+09	.82307E+07	.90286E+10
1275.	0.0119	.14033E+09	.28065E+07	.91689E+10
1325.	0.0081	.14333E+09	.28666E+07	.93122E+10
1375.	0.0053	.97175E+08	.19435E+07	.94094E+10
1425.	0.0033	.12032E+09	.24064E+07	.95297E+10
1475.	0.0019	.13576E+09	.27152E+07	.96655E+10
1525.	0.0011	.14146E+09	.28291E+07	.98069E+10
1575.	0.0006	.15815E+09	.31630E+07	.99651E+10
1625.	0.0003	.13899E+09	.27798E+07	.10104E+11
1675.	0.0002	.11988E+09	.23977E+07	.10224E+11
1725.	0.0001	.93953E+08	.18791E+07	.10318E+11
1775.	0.0000	.33211E+08	.13284E+07	.10351E+11
1800.	0.0000	.57750E+08	.11550E+07	.10409E+11
1850.	0.0000	.32240E+08	.64481E+06	.10441E+11
1900.	0.0000	.17302E+08	.34605E+06	.10458E+11
1950.	0.0000	.93545E+07	.18709E+06	.10468E+11
2000.	0.0000	.50260E+07	.10052E+06	.10473E+11
2050.	0.0000	.10300E+07	.20600E+05	.10474E+11

COPPER

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
890.	0.1225	.49018E+09	.23342E+08	.49018E+09
911.	0.1083	.13532E+09	.15035E+08	.62550E+09
920.	0.1026	.15397E+09	.51325E+07	.77947E+09
950.	0.0860	.47291E+09	.11823E+08	.12524E+10
990.	0.0679	.33947E+09	.91748E+07	.15918E+10
1027.	0.0551	.21474E+09	.16518E+08	.18066E+10
1040.	0.0512	.24071E+09	.48141E+07	.20473E+10
1090.	0.0388	.17055E+09	.42637E+07	.22178E+10
1130.	0.0310	.25744E+09	.51489E+07	.24753E+10
1180.	0.0235	.12912E+09	.64558E+07	.26044E+10
1200.	0.0210	.24570E+09	.16380E+08	.28501E+10
1215.	0.0191	.51615E+10	.10323E+10	.80116E+10
1220.	0.0185	.48171E+09	.87584E+07	.84933E+10
1275.	0.0131	.15491E+09	.30982E+07	.86482E+10
1325.	0.0096	.16988E+09	.33977E+07	.88181E+10
1375.	0.0070	.12841E+09	.25683E+07	.89465E+10
1425.	0.0051	.18962E+09	.37925E+07	.91362E+10
1475.	0.0037	.27295E+09	.54590E+07	.94091E+10
1525.	0.0027	.36282E+09	.72564E+07	.97719E+10
1575.	0.0020	.51747E+09	.10349E+08	.10289E+11
1625.	0.0014	.59951E+09	.11990E+08	.10889E+11
1675.	0.0010	.70445E+09	.14089E+08	.11593E+11
1725.	0.0007	.75206E+09	.15041E+08	.12345E+11
1775.	0.0005	.36215E+09	.14486E+08	.12708E+11
1800.	0.0004	.73500E+09	.14700E+08	.13443E+11
1850.	0.0003	.76917E+09	.15383E+08	.14212E+11
1900.	0.0002	.77379E+09	.15476E+08	.14986E+11
1950.	0.0002	.78420E+09	.15684E+08	.15770E+11
2000.	0.0001	.78980E+09	.15796E+08	.16560E+11
2050.	0.0001	.80477E+09	.16095E+08	.17364E+11
2100.	0.0001	.79917E+09	.15983E+08	.18163E+11
2150.	0.0000	.83570E+09	.16714E+08	.18999E+11
2200.	0.0000	.82880E+09	.16576E+08	.19828E+11
2250.	0.0000	.81871E+09	.16374E+08	.20647E+11
2300.	0.0000	.55599E+09	.11120E+08	.21203E+11
2350.	0.0000	.38879E+09	.77758E+07	.21591E+11
2400.	0.0000	.30498E+09	.60996E+07	.21896E+11
2450.	0.0000	.22427E+09	.44854E+07	.22121E+11
2500.	0.0000	.19335E+09	.38670E+07	.22314E+11
2550.	0.0000	.18035E+09	.36071E+07	.22494E+11
2600.	0.0000	.16950E+09	.33900E+07	.22664E+11
2650.	0.0000	.15615E+09	.31230E+07	.22820E+11
2700.	0.0000	.11468E+09	.22936E+07	.22935E+11
2750.	0.0000	.78059E+08	.15612E+07	.23013E+11
2800.	0.0000	.68310E+08	.13662E+07	.23081E+11
2850.	0.0000	.70274E+08	.14055E+07	.23151E+11
2900.	0.0000	.65073E+08	.13015E+07	.23216E+11
2950.	0.0000	.48534E+08	.97067E+06	.23265E+11

COPPER - BERYLLIUM

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
810.	0.1801	.45026E+09	.15009E+08	.45026E+09
840.	0.1534	.30681E+09	.15340E+08	.75707E+09
860.	0.1378	.57893E+09	.19298E+08	.13360E+10
890.	0.1174	.46962E+09	.22363E+08	.18056E+10
911.	0.1049	.13116E+09	.14574E+08	.19368E+10
920.	0.1000	.15000E+09	.50000E+07	.20868E+10
950.	0.0815	.44838E+09	.11210E+08	.25352E+10
990.	0.0621	.31043E+09	.83901E+07	.28456E+10
1027.	0.0467	.18214E+09	.14011E+08	.30277E+10
1040.	0.0421	.19776E+09	.39553E+07	.32255E+10
1090.	0.0282	.12396E+09	.30989E+07	.33495E+10
1130.	0.0203	.16819E+09	.33638E+07	.35177E+10
1180.	0.0134	.73563E+08	.36781E+07	.35912E+10
1200.	0.0113	.13253E+09	.88353E+07	.37237E+10
1215.	0.0100	.27000E+10	.54000E+09	.64237E+10
1220.	0.0094	.24512E+09	.44567E+07	.66689E+10
1275.	0.0049	.58168E+08	.11634E+07	.67270E+10
1325.	0.0027	.48382E+08	.96764E+06	.67754E+10
1375.	0.0015	.27687E+08	.55374E+06	.68031E+10
1425.	0.0008	.28962E+08	.57923E+06	.68321E+10
1475.	0.0003	.25255E+08	.50510E+06	.68573E+10
1525.	0.0001	.17737E+08	.35475E+06	.68751E+10
1575.	0.0000	.11658E+08	.23317E+06	.68867E+10
1625.	0.0000	.52275E+07	.10455E+06	.68919E+10
1675.	0.0000	.90779E+06	.18156E+05	.68928E+10

GOLD

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
860.	0.1191	.50028E+09	.16676E+08	.50028E+09
890.	0.1045	.41788E+09	.19899E+08	.91816E+09
911.	0.0960	.12000E+09	.13333E+08	.10382E+10
920.	0.0928	.13927E+09	.46424E+07	.11774E+10
950.	0.0831	.45686E+09	.11422E+08	.16343E+10
990.	0.0716	.35804E+09	.96768E+07	.19923E+10
1027.	0.0603	.23534E+09	.18103E+08	.22277E+10
1040.	0.0566	.26589E+09	.53179E+07	.24936E+10
1090.	0.0441	.19421E+09	.48551E+07	.26878E+10
1130.	0.0351	.29099E+09	.58197E+07	.29788E+10
1180.	0.0259	.14269E+09	.71345E+07	.31215E+10
1200.	0.0230	.26910E+09	.17940E+08	.33906E+10
1215.	0.0203	.54807E+10	.10961E+10	.88712E+10
1220.	0.0195	.50624E+09	.92043E+07	.93774E+10
1275.	0.0123	.14532E+09	.29063E+07	.95228E+10
1325.	0.0074	.13099E+09	.26199E+07	.96538E+10
1375.	0.0041	.74181E+08	.14836E+07	.97279E+10
1425.	0.0017	.62297E+08	.12459E+07	.97902E+10
1475.	0.0014	.99876E+08	.19975E+07	.98901E+10
1525.	0.0012	.15771E+09	.31543E+07	.10048E+11
1575.	0.0010	.25653E+09	.51306E+07	.10304E+11
1625.	0.0008	.34980E+09	.69960E+07	.10654E+11
1675.	0.0007	.49925E+09	.99850E+07	.11153E+11
1725.	0.0006	.64606E+09	.12921E+08	.11799E+11
1775.	0.0005	.37632E+09	.15053E+08	.12176E+11
1800.	0.0005	.84000E+09	.16800E+08	.13016E+11
1850.	0.0004	.10342E+10	.20684E+08	.14050E+11
1900.	0.0003	.12240E+10	.24480E+08	.15274E+11
1950.	0.0003	.14262E+10	.28524E+08	.16700E+11
2000.	0.0002	.16514E+10	.33028E+08	.18352E+11
2050.	0.0002	.19091E+10	.38182E+08	.20261E+11
2100.	0.0001	.21509E+10	.43017E+08	.22411E+11
2150.	0.0001	.25518E+10	.51036E+08	.24963E+11
2200.	0.0001	.28712E+10	.57424E+08	.27834E+11
2250.	0.0001	.30267E+10	.60534E+08	.30861E+11
2300.	0.0001	.21934E+10	.43869E+08	.33055E+11
2350.	0.0000	.16368E+10	.32737E+08	.34691E+11
2400.	0.0000	.13702E+10	.27404E+08	.36062E+11
2450.	0.0000	.10891E+10	.21782E+08	.37151E+11
2500.	0.0000	.10150E+10	.20299E+08	.38166E+11
2550.	0.0000	.10234E+10	.20467E+08	.39189E+11
2600.	0.0000	.10396E+10	.20792E+08	.40229E+11
2650.	0.0000	.99940E+09	.19988E+08	.41228E+11
2700.	0.0000	.76593E+09	.15319E+08	.41994E+11
2750.	0.0000	.54403E+09	.10881E+08	.42538E+11
2800.	0.0000	.49680E+09	.99360E+07	.43035E+11
2850.	0.0000	.51251E+09	.10250E+08	.43547E+11
2900.	0.0000	.47590E+09	.95180E+07	.44023E+11
2950.	0.0000	.35594E+09	.71187E+07	.44379E+11
3000.	0.0000	.25480E+09	.50960E+07	.44634E+11
3050.	0.0000	.19180E+09	.38361E+07	.44826E+11
3100.	0.0000	.14252E+09	.28504E+07	.44968E+11
3150.	0.0000	.99061E+08	.19812E+07	.45067E+11
3200.	0.0000	.69980E+08	.13980E+07	.45137E+11

NICKEL

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
911.	0.1125	.14069E+09	.15632E+08	.14069E+09
920.	0.1068	.16020E+09	.53399E+07	.30088E+09
950.	0.0897	.49316E+09	.12329E+08	.79404E+09
990.	0.0710	.35510E+09	.95974E+07	.11491E+10
1027.	0.0558	.21757E+09	.16736E+08	.13667E+10
1040.	0.0511	.24007E+09	.48014E+07	.16068E+10
1090.	0.0364	.16010E+09	.40025E+07	.17669E+10
1130.	0.0276	.22922E+09	.45844E+07	.19961E+10
1180.	0.0195	.10740E+09	.53702E+07	.21035E+10
1200.	0.0170	.19890E+09	.13260E+08	.23024E+10
1215.	0.0153	.41180E+10	.82359E+09	.64204E+10
1220.	0.0147	.38246E+09	.69538E+07	.68028E+10
1275.	0.0099	.11660E+09	.23319E+07	.69194E+10
1325.	0.0069	.12181E+09	.24362E+07	.70412E+10
1375.	0.0048	.87712E+08	.17542E+07	.71290E+10
1425.	0.0032	.12006E+09	.24011E+07	.72490E+10
1475.	0.0021	.15587E+09	.31174E+07	.74049E+10
1525.	0.0014	.18687E+09	.37374E+07	.75917E+10
1575.	0.0009	.24039E+09	.48077E+07	.78321E+10
1625.	0.0006	.25303E+09	.50606E+07	.80852E+10
1675.	0.0004	.27211E+09	.54421E+07	.83573E+10
1725.	0.0003	.26587E+09	.53174E+07	.86231E+10
1775.	0.0002	.11717E+09	.46869E+07	.87403E+10
1800.	0.0001	.22750E+09	.45500E+07	.89678E+10
1850.	0.0001	.20301E+09	.40602E+07	.91708E+10
1900.	0.0000	.17414E+09	.34829E+07	.93450E+10
1950.	0.0000	.15049E+09	.30098E+07	.94955E+10
2000.	0.0000	.12924E+09	.25848E+07	.96247E+10
2050.	0.0000	.11318E+09	.22636E+07	.97379E+10
2100.	0.0000	.96598E+08	.19320E+07	.98345E+10
2150.	0.0000	.86818E+08	.17364E+07	.99213E+10
2200.	0.0000	.74000E+08	.14800E+07	.99953E+10
2250.	0.0000	.63463E+08	.12693E+07	.10059E+11
2300.	0.0000	.37417E+08	.74833E+06	.10096E+11
2350.	0.0000	.22716E+08	.45431E+06	.10119E+11
2400.	0.0000	.15470E+08	.30940E+06	.10134E+11
2450.	0.0000	.10537E+08	.21073E+06	.10145E+11
2500.	0.0000	.84140E+07	.16828E+06	.10153E+11

PLATINUM

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
911.	0.0952	.11901E+09	.13224E+08	.11901E+09
920.	0.0915	.13719E+09	.45731E+07	.25620E+09
950.	0.0800	.44000E+09	.11000E+08	.69620E+09
990.	0.0669	.33460E+09	.90434E+07	.10308E+10
1027.	0.0561	.21864E+09	.16819E+08	.12495E+10
1040.	0.0526	.24722E+09	.49444E+07	.14967E+10
1090.	0.0412	.18111E+09	.45278E+07	.16778E+10
1130.	0.0338	.28079E+09	.56158E+07	.19586E+10
1180.	0.0265	.14560E+09	.72802E+07	.21042E+10
1200.	0.0240	.28080E+09	.18720E+08	.23850E+10
1215.	0.0219	.59143E+10	.11829E+10	.82993E+10
1220.	0.0212	.55245E+09	.10044E+08	.88517E+10
1275.	0.0152	.17936E+09	.35873E+07	.90311E+10
1325.	0.0112	.19842E+09	.39684E+07	.92295E+10
1375.	0.0083	.15130E+09	.30259E+07	.93808E+10
1425.	0.0058	.21552E+09	.43104E+07	.95963E+10
1475.	0.0039	.28619E+09	.57239E+07	.98825E+10
1525.	0.0026	.35095E+09	.70190E+07	.10233E+11
1575.	0.0019	.50619E+09	.10124E+08	.10740E+11
1625.	0.0018	.74750E+09	.14950E+08	.11487E+11
1675.	0.0016	.11389E+10	.22778E+08	.12626E+11
1725.	0.0015	.15766E+10	.31531E+08	.14203E+11
1775.	0.0014	.98440E+09	.39376E+08	.15187E+11
1800.	0.0013	.22750E+10	.45500E+08	.17462E+11
1850.	0.0011	.28809E+10	.57618E+08	.20343E+11
1900.	0.0010	.35070E+10	.70140E+08	.23850E+11
1950.	0.0008	.43008E+10	.86016E+08	.28151E+11
2000.	0.0007	.52414E+10	.10483E+09	.33392E+11
2050.	0.0006	.63009E+10	.12602E+09	.39693E+11
2100.	0.0005	.73820E+10	.14764E+09	.47075E+11
2150.	0.0004	.91074E+10	.18215E+09	.56182E+11
2200.	0.0004	.10656E+11	.21312E+09	.66838E+11
2250.	0.0003	.11798E+11	.23596E+09	.78636E+11
2300.	0.0002	.89800E+10	.17960E+09	.87616E+11
2350.	0.0002	.70382E+10	.14076E+09	.94655E+11
2400.	0.0001	.61880E+10	.12376E+09	.10084E+12
2450.	0.0001	.51516E+10	.10303E+09	.10599E+12
2500.	0.0001	.50283E+10	.10057E+09	.11102E+12
2550.	0.0001	.53101E+10	.10620E+09	.11633E+12
2600.	0.0000	.56500E+10	.11300E+09	.12198E+12
2650.	0.0000	.53194E+10	.10639E+09	.12730E+12
2700.	0.0000	.39927E+10	.79853E+08	.13129E+12
2750.	0.0000	.27774E+10	.55549E+08	.13407E+12
2800.	0.0000	.24840E+10	.49680E+08	.13656E+12
2850.	0.0000	.23375E+10	.46750E+08	.13889E+12
2900.	0.0000	.19799E+10	.39597E+08	.14087E+12
2950.	0.0000	.13507E+10	.27014E+08	.14222E+12
3000.	0.0000	.88200E+09	.17640E+08	.14311E+12
3050.	0.0000	.51975E+09	.10395E+08	.14363E+12
3100.	0.0000	.30233E+09	.60467E+07	.14393E+12
3150.	0.0000	.16451E+09	.32901E+07	.14409E+12
3200.	0.0000	.90870E+08	.18174E+07	.14418E+12

SILVER

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
911.	0.0993	.12410E+09	.13788E+08	.12410E+09
920.	0.0930	.13949E+09	.46496E+07	.26358E+09
950.	0.0748	.41128E+09	.10282E+08	.67487E+09
990.	0.0559	.27959E+09	.75566E+07	.95446E+09
1027.	0.0440	.17147E+09	.13190E+08	.11259E+10
1040.	0.0406	.19060E+09	.38120E+07	.13165E+10
1090.	0.0297	.13077E+09	.32692E+07	.14473E+10
1130.	0.0232	.19237E+09	.38474E+07	.16397E+10
1180.	0.0170	.93421E+08	.46711E+07	.17331E+10
1200.	0.0150	.17550E+09	.11700E+08	.19086E+10
1215.	0.0138	.37258E+10	.74515E+09	.56344E+10
1220.	0.0134	.34894E+09	.63443E+07	.59833E+10
1275.	0.0099	.11662E+09	.23324E+07	.60999E+10
1325.	0.0076	.13487E+09	.26974E+07	.62348E+10
1375.	0.0060	.10947E+09	.21893E+07	.63442E+10
1425.	0.0048	.17667E+09	.35334E+07	.65209E+10
1475.	0.0039	.28291E+09	.56581E+07	.68038E+10
1525.	0.0031	.41835E+09	.83669E+07	.72222E+10
1575.	0.0026	.66377E+09	.13275E+08	.78859E+10
1625.	0.0021	.87048E+09	.17410E+08	.87564E+10
1675.	0.0017	.11781E+10	.23562E+08	.99345E+10
1725.	0.0014	.14486E+10	.28972E+08	.11383E+11
1775.	0.0011	.80344E+09	.32138E+08	.12187E+11
1800.	0.0010	.17500E+10	.35000E+08	.13937E+11
1850.	0.0008	.21527E+10	.43054E+08	.16089E+11
1900.	0.0007	.25456E+10	.50912E+08	.18635E+11
1950.	0.0006	.30325E+10	.60650E+08	.21667E+11
2000.	0.0005	.35900E+10	.71800E+08	.25257E+11
2050.	0.0004	.44551E+10	.89101E+08	.29712E+11
2100.	0.0004	.53880E+10	.10776E+09	.35100E+11
2150.	0.0003	.68619E+10	.13724E+09	.41962E+11
2200.	0.0003	.82880E+10	.16576E+09	.50250E+11
2250.	0.0002	.98207E+10	.19641E+09	.60071E+11
2300.	0.0002	.80000E+10	.16000E+09	.68071E+11
2350.	0.0002	.66431E+10	.13286E+09	.74714E+11
2400.	0.0001	.61880E+10	.12376E+09	.80902E+11
2450.	0.0001	.51311E+10	.10262E+09	.86033E+11
2500.	0.0001	.49883E+10	.99766E+08	.91021E+11
2550.	0.0001	.48474E+10	.96948E+08	.95869E+11
2600.	0.0000	.47460E+10	.94920E+08	.10061E+12
2650.	0.0000	.42938E+10	.85877E+08	.10491E+12
2700.	0.0000	.30970E+10	.61940E+08	.10801E+12
2750.	0.0000	.17724E+10	.35448E+08	.10978E+12
2800.	0.0000	.13041E+10	.26082E+08	.11108E+12
2850.	0.0000	.98984E+09	.19797E+08	.11207E+12
2900.	0.0000	.67625E+09	.13525E+08	.11275E+12
2950.	0.0000	.37213E+09	.74426E+07	.11312E+12
3000.	0.0000	.19600E+09	.39200E+07	.11332E+12
3050.	0.0000	.93676E+08	.18735E+07	.11341E+12

TANTALUM

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
911.	0.1464	.18295E+09	.20328E+08	.18295E+09
920.	0.1435	.21518E+09	.71726E+07	.39813E+09
950.	0.1342	.73790E+09	.18448E+08	.11360E+10
990.	0.1227	.61354E+09	.16582E+08	.17496E+10
1027.	0.1037	.40462E+09	.31124E+08	.21542E+10
1040.	0.0967	.45462E+09	.90923E+07	.26088E+10
1090.	0.0739	.32506E+09	.81264E+07	.29339E+10
1130.	0.0587	.48749E+09	.97498E+07	.34214E+10
1180.	0.0438	.24112E+09	.12056E+08	.36625E+10
1200.	0.0390	.45630E+09	.30420E+08	.41188E+10
1215.	0.0327	.88236E+10	.17647E+10	.12942E+11
1220.	0.0308	.80105E+09	.14565E+08	.13743E+11
1275.	0.0161	.19012E+09	.38025E+07	.13934E+11
1325.	0.0089	.15827E+09	.31655E+07	.14092E+11
1375.	0.0050	.90865E+08	.18173E+07	.14183E+11
1425.	0.0027	.99581E+08	.19916E+07	.14282E+11
1475.	0.0014	.10396E+09	.20791E+07	.14386E+11
1525.	0.0008	.10021E+09	.20043E+07	.14486E+11
1575.	0.0004	.10366E+09	.20731E+07	.14590E+11
1625.	0.0002	.88729E+08	.17746E+07	.14679E+11
1675.	0.0001	.78477E+08	.15695E+07	.14757E+11
1725.	0.0001	.63065E+08	.12613E+07	.14820E+11
1775.	0.0000	.22859E+08	.91435E+06	.14843E+11
1800.	0.0000	.40250E+08	.80500E+06	.14883E+11
1850.	0.0000	.31566E+08	.63133E+06	.14915E+11
1900.	0.0000	.23798E+08	.47596E+06	.14939E+11
1950.	0.0000	.18075E+08	.36149E+06	.14957E+11
2000.	0.0000	.13642E+08	.27284E+06	.14971E+11
2050.	0.0000	.10373E+08	.20747E+06	.14981E+11
2100.	0.0000	.76875E+07	.15375E+06	.14989E+11
2150.	0.0000	.59992E+07	.11998E+06	.14995E+11
2200.	0.0000	.44400E+07	.88800E+05	.14999E+11

TUNGSTEN

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
890.	0.1446	.57658E+09	.27551E+08	.57858E+09
911.	0.1292	.16148E+09	.17942E+08	.74005E+09
920.	0.1231	.18461E+09	.61535E+07	.92406E+09
950.	0.1047	.57593E+09	.14398E+08	.15006E+10
990.	0.0844	.42213E+09	.11409E+08	.19227E+10
1027.	0.0672	.26210E+09	.20161E+08	.21848E+10
1040.	0.0618	.29044E+09	.58088E+07	.24752E+10
1090.	0.0447	.19690E+09	.49225E+07	.26721E+10
1130.	0.0346	.28690E+09	.57380E+07	.29590E+10
1180.	0.0250	.13767E+09	.68837E+07	.30967E+10
1200.	0.0220	.25740E+09	.17160E+08	.33541E+10
1215.	0.0195	.52646E+10	.10529E+10	.86187E+10
1220.	0.0187	.48697E+09	.88539E+07	.91057E+10
1275.	0.0120	.14197E+09	.28394E+07	.92476E+10
1325.	0.0080	.14241E+09	.28482E+07	.93900E+10
1375.	0.0054	.98463E+08	.19693E+07	.94885E+10
1425.	-0.0034	.12691E+09	.25382E+07	.96154E+10
1475.	0.0021	.15216E+09	.30431E+07	.97676E+10
1525.	0.0013	.16846E+09	.33692E+07	.99360E+10
1575.	0.0008	.20012E+09	.40024E+07	.10136E+11
1625.	0.0004	.18127E+09	.36253E+07	.10317E+11
1675.	0.0002	.15631E+09	.31262E+07	.10474E+11
1725.	0.0001	.12247E+09	.24494E+07	.10596E+11
1775.	0.0001	.43281E+08	.17312E+07	.10639E+11
1800.	0.0000	.75250E+08	.15050E+07	.10715E+11
1850.	0.0000	.49792E+08	.99584E+06	.10765E+11
1900.	0.0000	.31672E+08	.63344E+06	.10796E+11
1950.	0.0000	.20295E+08	.40590E+06	.10816E+11
2000.	0.0000	.12924E+08	.25848E+06	.10829E+11
2050.	0.0000	.79234E+07	.15847E+06	.10837E+11
2100.	0.0000	.47341E+07	.94682E+05	.10842E+11
2150.	0.0000	.29786E+07	.59572E+05	.10845E+11

ZINC

WAVE	YIELD	EMM/BAND	EMM/A	TOTAL
810.	0.1354	.33842E+09	.11281E+08	.33842E+09
840.	0.1224	.24474E+09	.12237E+08	.58316E+09
860.	0.1144	.46051E+09	.16017E+08	.10637E+10
890.	0.1034	.41369E+09	.19699E+08	.14774E+10
911.	0.0950	.11881E+09	.13201E+08	.15962E+10
920.	0.0912	.13676E+09	.45587E+07	.17329E+10
950.	0.0794	.43655E+09	.10914E+08	.21695E+10
990.	0.0660	.32990E+09	.89161E+07	.24994E+10
1027.	0.0536	.20899E+09	.16076E+08	.27084E+10
1040.	0.0496	.23298E+09	.46596E+07	.29413E+10
1090.	0.0367	.16163E+09	.40408E+07	.31030E+10
1130.	0.0289	.23990E+09	.47981E+07	.33429E+10
1180.	0.0214	.11781E+09	.58904E+07	.34607E+10
1200.	0.0190	.22230E+09	.14820E+08	.36830E+10
1215.	0.0167	.45187E+10	.90375E+09	.82017E+10
1220.	0.0160	.41712E+09	.75840E+07	.86188E+10
1275.	0.0101	.11889E+09	.23777E+07	.87377E+10
1325.	0.0066	.11683E+09	.23366E+07	.88545E+10
1375.	0.0043	.79132E+08	.15826E+07	.89337E+10
1425.	0.0026	.96400E+08	.19280E+07	.90301E+10
1475.	0.0014	.10539E+09	.21078E+07	.91355E+10
1525.	0.0008	.10640E+09	.21280E+07	.92419E+10
1575.	0.0004	.11526E+09	.23052E+07	.93571E+10
1625.	0.0002	.93372E+08	.18674E+07	.94505E+10
1675.	0.0001	.70626E+08	.14125E+07	.95211E+10
1725.	0.0000	.48538E+08	.97075E+06	.95697E+10
1775.	0.0000	.15046E+08	.60183E+06	.95847E+10
1800.	0.0000	.24500E+08	.49000E+06	.96092E+10
1850.	0.0000	.11731E+08	.23463E+06	.96209E+10
1900.	0.0000	.54000E+07	.10800E+06	.96263E+10
1950.	0.0000	.18739E+07	.37477E+05	.96282E+10
2000.	0.0000	.64620E+06	.12924E+05	.96289E+10